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the RESEARCH Quarterly

PUBLISHED BY THE AMERICAN ASSOCIATION FOR HEALTH, PHYSICAL EDUCATION & RECREATION

1201 SIXTEENTH ST., N. W., WASHINGTON, D. C.

The Research Quarterly

of the American Association for Health, Physical Education, and Recreation

Volume 21 DECEMBER, 1950 Number 4

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Published in March, May, October, and December by the American Association for Health, Physical Education, and Recreation, 1201 Sixteenth Street, N.W., Washington 6, D. C. Subscription $3.00 per year; single copies, $1.00

Send subscriptions to 1201 Sixteenth Street, N.W., Washington 6, D. C. Editorial office: 1201 Sixteenth Street, N.W., Washington, D. C. Entered as second-class matter at the Post Office at Washington, D. C., under the act of March 3, 1879. Additional entry at Baltimore, Md.

Batting Reaction-Time

A. T. Slater-Hammel
Indiana University
R. L. Stumpner
Indiana University

THE PRESENT investigation has grown out of discussions with a number of baseball coaches and players concerning the factors which make for success in batting. In these discussions, it has been commonly stated that the successful batter is one who has learned to delay his swing until the last fraction of a second. In fact, some have stated that the swing should not begin until the ball is within the last few feet of home base. In doing this, the batter is supposed to gain precise knowledge of where the ball will cross the home base and thus have a better chance for a successful contact.

It has been the feeling of the writers, however, that the "last fraction of a second" or the "last few feet of home base" may be greater than commonly imagined. In batting, a player must react to a ball in flight, and it would seem that a reaction-time factor must enter. Even if this reaction-time were of the order of a simple hand response to a visual stimulus, it would amount to .150–.225 second (1), and constitute a considerable interval of time. Furthermore, in view of the fact that a fast ball travels from pitcher to home base in approximately .43–.58 seconds (2), it becomes evident that a ball must be more than a few feet from home plate if the batter is to have time to react to it.

As far as the writers have been able to ascertain, there have been no studies of batting reaction-time. The study herein reported represents an attempt to measure this reaction-time under two experimental conditions. One condition, hereafter referred to as the starting reaction-time, involved a measure of the speed with which a subject could start a bat moving upon the presentation of a visual stimulus. The other condition, hereafter referred to as the movement reaction-time, involved a measure of the speed with which a subject could change the direction of a moving bat upon the presentation of a visual stimulus.

Method and Procedures

Apparatus. A specially constructed wooden rail, 42 inches high and forming a 180 degree arc with a 48 inches radius, provided a horizontal surface across which a bat was swung. Twelve sections of aluminum I-beam were mounted end-to-end along the top of the rail. These sections marked off 15 degree intervals and provided a metal contact for the bat. A vertical

block mounted at the right end of the rail provided a starting point for the swing and another metal contact.

A regulation baseball bat, 35 inches long and weighing 35 ounces, was used throughout the experiment. The upper half of the bat was covered with a sheet of flexible copper and served to complete a circuit with either the starting block or the aluminum sections.

The visual stimulus to which the subject reacted consisted of a 105–125 volt neon glow lamp. This lamp was mounted 60 inches beyond the left end of the rail and 54 inches from the floor. A .01 second standard electric clock served to record the reaction-time.

To record the starting reaction-time, the electrical circuit was wired so that when the experimenter threw a knife-switch the neon lamp was lighted and the clock was started. Movement of the bat from the starting block broke the circuit and stopped the clock.

In recording the movement reaction-time, the electrical circuit was wired so that movement of the bat across the rail controlled the instant at which the lamp and clock were activated. Lifting the bat off the rail stopped the clock.

A simple switching arrangement made it possible to vary systematically the point along the rail at which the bat closed the lamp and clock circuit. Preliminary trials showed that when the lamp and clock were started beyond the 90 degree point of the movement excursion the bat usually went off the rail before the subject could react; consequently, the points of circuit closing were limited to 15, 30, 45, 60, and 75 degrees.

Procedures. The starting reaction-time was measured by having the subject stand midway between the ends of the rail and facing the center of the arc it described. In this position a normal batting stance was assumed with the bat brought back until it rested against the starting block. At the signal "Ready," the subject concentrated on the lamp directly in line with his left shoulder. Upon the appearance of the light, the subject swung the bat forward and away from the starting block. The time interval between the signal, "Ready," and the appearance of the light was varied during the series of trials. The intervals were approximately one, two, and three seconds arranged in random order. These intervals were estimated by the experimenter through the use of sub-vocal counting, and were not exact.

In measuring the movement reaction-time, the subject assumed the general position described above. At the signal "Go," the subject swung the bat along the rail and concentrated on the lamp. Upon the appearance of the light, the bat was swung upward and off the rail.

Each subject was given 25 consecutive trials in the two reaction-time situations. An explanation and demonstration was given by the experimenter before each series of trials. Following this, the subject was given practice until it became evident he thoroughly understood the desired reaction.

Subjects. Twenty-five male physical education majors of Indiana Uni-

versity served as subjects. Their ages ranged from 20 to 29 years, their median being 24.5. All subjects were right-handed, and all had had many years of baseball experience.

Results and Discussion

Table 1 summarizes the data on starting and movement reaction-time in batting. For the subjects in this experiment, the starting reaction-time was approximately .21 seconds and the movement reaction-time .27 seconds. It is of interest to note that, despite the differences in masses involved, the starting reaction-time is within the upper limits of the time for a simple hand response (.150–.225 seconds). The movement reaction-time, however, is greater than a simple hand response.

That the difference between starting and movement reaction-time is significant is revealed by a t value of 4.855. For 24 degrees of freedom, a t value of 2.797 is significant at the 1% level of confidence. The hypothesis that this difference can be attributed to chance is thus rejected.

TABLE 1

Data on starting and movement reaction-time (in seconds)

	Mean	σM
Starting R. T.	.206	.003
Movement R. T.	.269	.005
Difference	.063	
t	4.855	
P	.01	

Insofar as the kind of reactions studies in this experiment are involved in an actual batting situation, it would appear to be advantageous for a batter to make his reaction to a ball in flight a starting, rather than a movement reaction. This would enable him to observe the ball a little longer, and it would, presumably, lead to greater batting success.

However, even though a starting reaction were used it would not mean that a batter could delay his swing until the ball was within the "last few feet of home base." Scott (2) cites data indicating that a fast overhand throw requires from .43–.58 seconds to travel from the pitcher to home base. If these figures are taken as representing the average time of baseball throw, and if a batter must react to a ball in flight during this interval, it becomes evident that the ball must be more than a few feet from home base for a successful reaction. To have sufficient time for a starting reaction, the ball would have to be from 22 feet to 30 feet from home base. A movement reaction would require that the ball be from 28 feet to 38 feet from home base. These distances of course, assume that the ball travels at constant speed. Actually, it would probably be slowed down to some extent by air resistance, and this would tend to shorten the distances

necessary for a successful reaction. On the other hand, it requires some time to bring the bat forward after starting the movement, and this would have to be added to the reaction-time.

The starting and movement reaction-times found in this study are not presented as being wholly representative of batting reaction-time; they are simply presented as possible minimal limits. The two experimental conditions involved in a simple reaction, and an actual batting situation may involve choice reactions, *i.e.*, the batter may have to react to a ball which moves upward, downward, and so on. Since all reaction-time studies show that choice reactions require more time than simple reactions, it is possible that batting reaction-time in a game situation is greater than found in this study.

Summary

The batting reaction-times for 25 physical education majors were measured under two experimental conditions. It was found that the mean starting reaction-time was approximately .21 seconds and the mean movement reaction-time .27 seconds. Some implications in batting under game conditions were noted.

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A Theoretical and Practical Use of Dry Heat in the Treatment of Dermatophytosis

WILLIAM H. GROVES
North Georgia College
Dahlonega, Georgia

THE PREVALENCE of dermatophytosis during World War II among the Armed Forces was exceptionally high. Weidman and others, (14) found that no less than 8% of all hospital admissions in the Army and Navy were for cutaneous disease and that dermatophytosis ranked second on the list. Montgomery and Casper (6) state, that between 1940 and 1943, the Navy hospitalized 14,068 patients for fungus infections of the skin. They go on to state that these patients lost 251,418 days from active service, representing 17.1% of sick days lost for all skin diseases.

The importance of dermatophytosis appearing in industry is brought out by Peck and others, (7). In this study, 2123 cases were involved. It has been estimated, from this study, that 50% of the personnel in industry is affected by the condition.

The prevalence of dermatophytosis among students is well-known by all who have a part in conducting physical educational activities. It is for this reason that the common term "Athlete's itch" or "Athlete's foot" has such wide popular acceptance.

Some Disadvantages in Present Methods of Treatment

The present methods used in treating dermatophytosis are classified by Lewis and Hopper (4) into the following groups:

1. Topical applications. These include fungicides, keratolytics, and soothing agents.
2. Physical agents. These include the use of ultraviolet and Roentgen rays.
3. Biological methods. This grouping refers to the use of injections of trichophytin, and the implantation of harmless saprophytes beneath the skin.

The wide range of methods of treatment, as is shown above, indicates the obvious fact that no one method of successful treatment of dermatophytosis has been discovered.

In the use of topical applications, White (16) lists several preparations that he used in his medical practice, and then makes this statement, "This long, varied list signifies only one thing—a confession of therapeutic weakness."

Semon (9) considers the use of antiseptics as useless in treatment in that

such an agent will not penetrate the keratin and in addition, that most of the antiseptics used will actually irritate the skin. He favors salicylic acid dissolved in spirit.

Sutton (11) observes that Whitfield's ointment was at one time considered a specific, but that this belief has been since changed. He says that such preparations as this are valuable but lack much of being panaceas.

Henrici (2) points out that the use of iodides has no effect upon the fungus itself, but reacts on the tissue. He says, "...although apparent cures and improvements under such treatments have been reported, the results in general are not sufficiently striking that any specific chemotherapeutic agent has been discovered."

McKee (5) states that during and after the recent war, much research was conducted in order to find a superior remedy for dermatophytosis. This, he says, resulted in almost innumerable lotions, ointments, and powders, many of which are useful, but that no satisfactory curative and prophylactic remedy has been found.

Weidman (13), in writing about topical applications says that often four or five applications must be used before one is successful in clearing up the case.

Jacobsen (3) lists 10 different topical applications that might be used for treating dermatophytosis, and adds that there are many other applications used by different dermatologists.

In the acute active stages of dermatophytosis of the feet, military doctors (8) recommend for simplified treatment potassium permanganate, foot powder, weak sulphur-resorcin lotion, and silver nitrate solution.

Andrews (1) warns that great care must be taken in the use of Roentgen rays on recurring attacks of dermatophytosis in order to prevent radiodermatitis from resulting.

Sequeira and his associates (10) hold the opinion that Roentgen treatment is useless unless incorporated into a broad therapeutic plan. They also point out that Roentgen rays have no effect on fungi, but that such treatment may improve the eczematoid reaction, if present.

Lewis and Hopper (4) contend that ultraviolet radiation has little or no value in treating dermatophytosis, and if the disease is of an inflamed type, an eczematous condition may result.

The use of biological methods in the treatment of dermatophytosis is still in the experimental stage. Andrews (1) states that the biological attack in the use of fungus vaccines has proved disappointing.

From the number of highly advertised "remedies" that exist today, one can easily agree with White, that such an imposing array is indicative of therapeutic weakness.

A Theory in the Use of Dry Heat in the Treatment of Dermatophytosis

Several years ago, the author's attention was drawn to the fact that ironing of clothes is performed primarily as a means of sterilization. It

occurred to the author that this application of heat could also be applied to the treatment of dermatophytosis. Thereafter, when the author had a case of dermatophytosis, he would take a screwdriver, heat the flattened end to a degree of temperature that just barely could be withstood by the skin, and placed it between the afflicted toes. A sterile handkerchief was placed between the skin and the screwdriver end to prevent possible infection.

The flattened part of the screwdriver was moved in between and around the afflicted toes until the heat began to dissipate itself, whereupon, the screwdriver end was reheated, and the process repeated. A stop watch was used and the exact amount of time that the heat was actually being applied was recorded until a total of 10 minutes had been reached. Itching, when present, ceased immediately and a unique feeling of relief in the area was noted. In some instances when necrotic tissue was present it remained dry after treatment, and after the normal peeling process, left the skin in healthy condition. No blistering was ever encountered.

In order to check this method more accurately, the author allowed subsequent recurring attacks of dermatophytosis to reach a more advanced stage. The same process was followed in the use of the heated screwdriver, and in each case, the afflicted area was brought back to normal in a very short time. The total time between the initial treatment and curative stage, while not accurately gauged, averaged between two and three weeks.

Through several such personal experiments it was found that three 10-minute treatments were all that were necessary to bring about a complete cure. The author feels that one 10-minute treatment would be sufficient if all the afflicted area could be heated at the same time. But, with the screwdriver method, the heated end is not in contact with all the afflicted area at one time, so three treatments seemed necessary in order to reach the whole area mentioned.

The author believed that if this method of treatment was successful in one case it should be in others. However, the question as to whether the fungi were killed by the degree of heat that the skin could normally bear, was a paramount issue. Consequently, a search of medical literature was made in the attempt to find the thermal death-point of the fungi causing dermatophytosis.

The most complete work conducted along these lines, that the author could find, was performed by Dr. Fred D. Weidman (12). He found that various types of fungi in culture were killed within 10 minutes at 48C and that some species were yet more susceptible and were killed within five minutes.

Weidman (13), in a later publication, suggested the possibility of using heat in the treatment of dermatophytosis. He says, in reference to his previous publication mentioned above: "I have also found in the laboratory that ringworm fungi do not withstand high temperatures—such as the

skin can bear. There is a possibility that, by baking the feet, we may clear up current attacks which have resisted parasiticide applications, but this treatment does not guarantee against recurrences."

A personal communication with Dr. Weidman revealed that he had never followed up his idea of baking the feet, and that to his knowledge this author was the first to suggest the use of dry heat in the treatment of dermatophytosis.

Thus encouraged, the author began a limited study to check the results of the use of dry heat.

Procedure for Arranging the Testing Apparatus

The use of an electrically controlled heating element, designed to fit between the toes with the heat held between 49–51C, would have been ideal for the test. However, the technical details involved for the time allotted for the test ruled out this procedure.

Instead, the use of hot water funneled through rubber and flattened copper tubing was used to produce the dry heat. This was accomplished by filling a 24 gallon container with water having a temperature of 50C. Through a series of rubber tubing connections, spaced at intervals with short lengths of flattened copper tubing, the water was siphoned through the tubes and allowed to bleed freely. The temperature of the water was checked both at the container and bleeding end of the tubing and held constant at 50C. The copper pieces were wrapped with sterile gauze for sanitary purposes. The heat transmitted through the copper pieces was applied to the affected areas of the skin. Thus, dry heat was made available for the test through this process.

Method of Selecting Test Cases

Men volunteers, who had dermatophytosis, were selected as test cases from among the student body. Those who had been treating themselves or had been under medical treatment were eliminated from the test. When all eliminations had been completed there were left 18 boys to be treated. With some boys having from two to three areas on each foot to be treated, the statistical tabulation will refer to these accumulative areas as cases. There were 51 of these cases.

The subjects were closely examined and the cases of dermatophytosis classified into three groupings. The groupings were lettered Type A, B, and C. The cases of dermatophytosis were classified into these three groups and were given the description, location, and distribution of each case.

Type A was chosen to classify those cases that were in the primary stage consisting of one or all of the following: small blisters; slight peeling of the skin; presence or absence of itching; and redness of the area.

Type B was chosen to classify those cases that were in the dormant stage consisting of one or all of the following: necrotic tissue; weeping or dry; and the presence or absence of itching.

Type C was chosen to classify those cases that were in the active state consisting of one or all of the following: necrotic, scaling tissue; weeping; itching or no itching; visible dermis; redness of the area; and fissures.

Method of Conducting the Test

The test subjects were given a mimeographed copy of instructions to follow in preventive treatment for the duration of the test.

The test was devised to use only three 10-minute treatments on each case, to be given once daily for three successive days. Three treatments were chosen as a "margin of safety" although it was thought that one treatment would suffice to produce the same results.

An additional use of the theory of dry heat was employed in the preventive measures. Each test participant was asked to bring all his shoes to the test area, at the beginning of the test. These shoes were placed on the top of a huge boiler where the heat registered 68–70C, and remained there for a 15-minute period.

It seemed to be a most logical procedure to follow in sterilizing the shoes, if the fact is accepted that most fungi causing dermatophytosis are killed at 48C. Perhaps the most widely used prophylaxis in sterilizing shoes that harbor the fungi, is formalin vapor. This method is discussed in an article based on a study of military personnel by Weidman and others (14). In view of the comparatively longer time necessary for sterilization by the use of formalin, dry heat would offer a distinct advantage. In addition, the use of dry heat would be within the reach of all, by simply putting the shoes in a baking oven and heating them for 10 or 15 minutes. Shoes will stand a much higher degree of heat than 48C, without injury.

Results of the Test with Dry Heat

It should be noted here that this test was conducted in the month of August on a summer type of dermatophytosis.

The results of the test are shown in Table 1. The method shown of grading the results follows that suggested by Wiedman and others (14), with the exception that a "cured" column was omitted in this test. A case of dermatophytosis can only be diagnosed as cured when microscopic examination of scrapings shows that no fungi are left after treatment. Since no such examination could be made, all those cases that appeared to be cured were classified as "almost cured."

In the "almost cured" and "improved" columns were placed those cases that had obviously gotten better. In the original examination, the areas of each of the toes were estimated and charted under "distribution" by an estimated number of square inches. Cases of "almost cured" were those of diminished areas, plus absence of the other noted clinical signs, such as "weeping," "itching," and so forth. In the "improved" column, reliance was placed, mostly, on absence of the previous clinical conditions present. In the "stationary" column were placed those cases which still presented

some of their original clinical conditions. In the "worse" column were placed those cases which had regressed from their original clinical condition.

The number of cases "almost cured" was 56.9%, the number of "improved" cases was 19.6%. When these two groups are combined we have a total of 76.5% of the cases that had been helped by the use of dry heat. In other words, more than three-fourths of the cases had been "almost cured" or "improved." Remaining "stationary" were 15.7% of the cases treated, and 8% were "worse." When these two groups are combined, it

TABLE 1

SUBJECT	CASES	TREATMENTS	TYPES	CASES ALMOST CURED	CASES IMPROVED	CASES STATIONARY	CASES WORSE
1	4	2	B B B B	B B B B			
2	2	3	B B	B B			
3	1	3	A	A			
4	3	3	B B C	C	B B		
5	3	3	A A B	A A B			
6	3	3	A A C	C	A A		
7	1	3	B	B			
8	1	3	B	B			
9	3	1	A A A	A	A A		
10	4	3	A A B B	A A B B			
11	5	3	B B C C C	B B C C C			
12	5	3	A A A A A	A A A	A A		
13	4	3	A A B C	A B	A C		
14	4	3	C C C C			C C C C	
15	2	1	A C			A C	
16	1	1	A			A	
17	1	1	B			B	
18	4	3	A A C C				A A C C
Total cases	51			56.9%	19.6%	15.7%	8%

is found that less than one-fourth of the cases treated received no apparent help.

As to the type of infection helped by the use of dry heat, it is found that Type A totaled 81%; Type B, 94%; and Type C, 46%. This information tends to show that Type C is more difficult to treat successfully. Type B seems to be the most responsive to treatment. This may be due to the ease of noting the clinical conditions and the improvement made within the area.

The final inspection was made 21 days after the initial treatment. Three inspections were held, once weekly, after treatment had started and only the last inspection results were tabulated for the study.

Dry Heat Treatment as Compared with Treatment by Medicaments

It would have been difficult under the existing conditions to have conducted a test of dermatophytosis wherein medicaments were used, for the purposes of comparing results. In one way, this was considered as unnecessary as such a test had been run previously by Weidman and Glass (15) on a group of prisoners. This study shall be briefly mentioned so that a comparison might be drawn between the use of medicaments and the use of dry heat. One fact should be noted in this comparison. The test with medicaments was conducted in the winter months while the dry heat test was conducted in the summer. A higher percentage of favorable results will be procured in a winter test due to the nature of the growth of fungi than can be obtained in a summer test.

Weidman and Glass performed their winter test on 117 prisoners. They had a total of two hundred experiences divided among the six medicaments (topical applications) selected for the test. Each medicament was given to a particular group of men, and was applied by themselves twice daily for two weeks. After four weeks, the men were given their first and last inspection for results. From the six medicaments, the control (boric acid powder) surprisingly showed the best results with 77.3%. This percent was gained by combining the "cured," "nearly cured," and "improved" groups out of a total of 49 experiences. However, the authors of the test felt that Cresatin was a better medicament which showed favorable results of a total of 73.7% in a total of 69 experiences.

Discussion

From the standpoint of the present methods used to treat dermatophytosis, no one treatment has outstanding merit. The use of topical applications appears to be a more popular method of treatment than any other.

The use of dry heat may prove to be a new approach to successful treatment of dermatophytosis. More study must be done along this line to bear out this contention. If we acknowledge the fact that most fungi are killed at a temperature that can be withstood by the skin, the use of dry heat treatment has possible high merits.

The use of dry heat as a prophylaxis seems to merit close attention. Shoes could easily be sterilized by heat in a matter of a few moments. The present method of doing this takes many hours by the use of formalin vapor. Shower room floors could be quickly sterilized by "sweeping" them with a comparatively high degree of heat.

The results of the limited study on the use of dry heat performed by the author (76.5%) compares favorably with those results obtained by Weidman and Glass (77.3%) in the use of six medicaments. The results of the dry heat test becomes more favorable when it is noted that it was conducted on a summer type of dermatophytosis.

It is a standard practice to drop from the tests, those subjects that fail to adhere to instructions given them. If such a practice had been

applied to the dry heat test, the favorable results would have totaled 82%.

Summary and Conclusions

The prevalence of dermatophytosis among college students, military forces, and industrial groups, is well-established. With this fact in mind, it becomes significant that no one method of treatment has been devised that is totally successful.

The possibility of a new approach in treatment is projected through the use of dry heat ranging between 48–55C. The main value supporting this theory is an established fact that most fungi are killed at a degree of temperature that can be withstood by the skin. This same procedure is suggested as a prophylatic treatment of shoes.

In a limited summer test conducted among 18 college students comprising a total of 51 experiences, the following conclusions were obtained:

1. In two and three treatments consisting of 10 minutes each, improvement was accomplished in 82% of a total 44 experiences. When those cases of only one treatment were included, improvement was noted in 76.5% of a total 51 experiences.
2. The dry heat proved most effective on Type B infection, showing 94% improvement. Dry heat was least effective on Type C, showing improvement of 46%.
3. The dry heat test compared favorably with a winter test conducted by Weidman and Glass wherein medicaments were used.

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Sex Differences in Anthropometric Measures and Ratios of College Students Aged 18 to 21[1]

RUSSELL L. STURZEBECKER
Department of Health and Physical Education
State Teachers College
West Chester, Pennsylvania

IT HAS been clear for some time that the physical proportions and capacities of men and women are quite different, and that an adequate physical and health education program should take these differences into consideration to a greater extent than has been done heretofore. But without adequate data on the nature and extent of these differences at specific age levels, no rational or adequate program of instruction can be erected.

The examination of previous literature has revealed the varied approaches employed in anthropometrical studies of individuals. A considerable range is presented with respect to measurements selected, techniques of measuring, subjects used, and treatment of collected data. Very early investigators were concerned with the general average measurements of somewhat homogeneous groups. Total population values were hypothesized from these simple means, which, on the whole, were not accompanied by measures of variability; thus their values were principally historic and intrinsic. Since it was the aim of this investigation to study the characteristics of contemporary college students, it appeared appropriate to review previous studies pertinent to this area of research.

In 1836, Forbes (1) drew attention to the importance of physical statistics in a paper read before the Royal Society of Edinburgh. His data were secured from the measurements of height, weight, and strength taken from 829 university students. One of the earliest collections of anthropometrical statistics of college men and women in the United States was made by Dickson (2). During 1857–1858, he published height and weight statistics of 780 college men from six colleges and universities. He also listed similar statistics of 166 girls from two academies. During the period 1861–1874, Hitchcock (3) secured measurements of 4311 students at Amherst. This extensive study was the greatest impetus for the use of anthropometry in the schools and colleges. Physical measurements appeared as an integral part of physical education programs.

[1] Abstract from a doctoral dissertation, Temple University, Philadelphia, Pennsylvania.

In 1875, Bowditch (4) initiated an anthropometrical study of the school children of Boston in which a total of 24,500 observations were made. At the same time, Francis Galton in England interested the faculty (5) of Marlborough College on the subject of physical measurements. As a result, 550 boys, aged 10 to 19 were made the subjects of body mensuration. In 1886, Sargent (6) at Harvard published an original Anthropometric Chart which served as a model for the recording of body measurements of college students. The use of anthropometry was further advanced by Tuckerman (7) in 1884–1885 when he made 3000 measurements of 52 college students at the Massachusetts Agricultural College.

During the period 1890–1900, Ladd (8) at Bryn Mawr, Hanna (9) at Oberlin, Gilbert (10) at Iowa, and Seaver (11) at Yale all contributed the results of their individual investigations to the growing area of educational anthropometry. In 1921, Baldwin (12) made a comprehensive study and computation of anthropometrical statistics concerning growth from birth to maturity. Since this study was completed, many other investigations have been made using subjects within the age group from birth to 17. Recent college studies in large part have been concerned principally with college populations as a whole rather than with specific age levels. An exception may be cited in a height and weight study of American college women published by Diehl (13) in 1933.

Purpose of the Present Study

This study is concerned with the determination of specific anthropometric measures of male and female college students aged 18 to 21. From the measures thus obtained, certain ratios would be derived and parameter values of both the measures and the ratios could be established. The chief considerations were: (a) a comparison of similarities and differences found to exist within the age groups of each sex, and (b) a comparison of similarities and differences existing between male and female students at the same age level. Finally the results obtained would be compared with the findings of earlier studies.

Procedures and Methods

The recommendations of leading anthropometrists such as Hrdlicka(14), Seaver (11), Baldwin (12), and Davenport (15) furnished sound bases for the limitation of measurements to be taken, techniques of measurement, and the construction of specific anthropometrical instruments.

In studies involving growth or differences in growth, Hrdlicka (14) recommends that attention be given mainly to the dimensions of the body as a whole and to its main segments including the limbs and trunk. In addition, for comparative studies, certain main body widths are important. Since all measurements necessitate the location of certain body landmarks, it is essential that these landmarks be easy to locate and, at the same time, exhibit little variability in the human body. From the latter point of view, Hrdlicka (14) and Davenport (15) state that the most reliable measure-

ments have been obtained from diameters or lengths between bony landmarks.

In light of the foregoing criteria, seven general anthropometrical measurements were chosen that would indicate any gross bodily differences present in the age groups under consideration. These measurements were weight, standing height, kneeling height, sitting height, span of the arms, bi-deltoid width, and bi-iliac width.

ANTHROPOMETRICAL INSTRUMENTS AND THEIR USE

Standard references of Davenport (15), Baldwin (12), Seaver (11), and Hrdlicka (14) were used as the bases of instrument selection. The service of an experienced gauge-maker was secured to aid in the design and construction of the required instruments. From the list of linear measurements, it was apparent that one instrument might feasibly measure the three heights, a second instrument could measure the two trunk widths, and a third would provide the readings for the span of the arms.

For psychological reasons, a double reading scale was planned for all length and width measurements. Accordingly, each instrument would have adjoining metric and English scalings so that two readings could be taken concurrently. The English reading would serve the interest of the subject and the metric reading would serve the purpose of the study.

For the three heights, a vertical stadiometer with a perpendicular sliding bar was constructed. A base support box with a housing received the lower end of the stadiometer rod. Portability was insured through the use of a lock screw which could pass through the housing walls and the vertical rod. This particular construction permitted the taking consecutively of sitting height, kneeling height, and standing height from the base box.

A width caliper with a stationary arm and a sliding arm was constructed for the taking of the transverse diameters. The arms of the instrument were of sufficient length so as to obviate any chances of the instrument rod contacting the subject's trunk.

For the securing of the span measurement, a wall spanmeter was developed with both a stationary arm and a sliding arm. Metal eyes were placed on the two ends of the instrument rod so that it could be readily hung from a firm support. In erecting the instrument, the use of a small bubble level insured a parallel relation of the rod to the floor. Both arms were projected through right angles above and below the instrument rod so that variations in shoulder heights of different subjects would not necessitate the elevation or depression of the instrument.

The inset metric and English scales for all instruments were purchased from commercial scientific supply firms. All instruments were certified as to their accuracy by a public bureau of standards official.

An investigation of weighing equipment available in the colleges selected for study revealed a lack of metric scales and a variability in both type and condition of scales in use. In order to overcome this variability and,

at the same time, meet the logistic problem, a portable English spring scale was obtained. This scale had a movable indicator which permitted ready adjustment to test weights. As with the linear instruments, this scale was also certified as to its accuracy. Weights were then taken and the resultant readings were converted to their metric equivalent.

The main source for techniques in taking measurements was found in "The International Agreement for the Unification of Anthropometric Measurements To Be Made on the Living Subject" as outlined by Hrdlicka (14). When the instruments were finally approved, a group of major health and physical education college students were selected as assistants in the securing of the data. A training program was organized so as to include familiarity with measuring instruments, recognition of landmarks, and actual practice in measuring.

It was further arranged that a pair of students would work with only one measurement. During the training period, the measurements made by each student were compared for reliability. It was found that after practice the personal error for each, as shown by the differences between their measurements, was reduced so as to become statistically insignificant.

RELIABILITY OF THE MEASURES

In the measurement of the living body, absolute precision is, of course, unattainable. However, it is possible to discover or anticipate certain sources of error and then attempt to create controls over them so that their effects may be minimized.

Earlier studies have in general revealed certain possible sources of error inherent in anthropometrical measurements. These are: (a) error in the instrument, (b) observational errors in locating and identifying landmarks, (c) error in the measurement of the distance between landmarks, (d) personal error between users of the instrument, (e) variations in the posture of the subject being measured, and (f) accidental errors in misreading instruments or in the recordings of figures.

In order to equate these types of possible errors and obtain reliable measures, the following steps were taken:

1. All instruments were carefully constructed or selected. All measuring scales were of printed wood which diminishes reading fatigue. All instruments were certified and were frequently checked for both accuracy and smoothness of operation throughout the study.

2. All measurements selected could be taken from easily recognized posture positions. These basic posture positions had as one of their main criteria a minimization of elements of fatigue on the part of the subject. For any particular measurement the same instructions were given to each subject.

3. All landmarks were clearly defined and located. Frequent checks were made during the process of examinations to insure continuous uniform interpretation of these.

4. All assistants received adequate practice in the use of these instru-

ments to the extent that measures of the reliability of their measurements indicated no significant differences between either the same measurement made between two individuals or the same measurement repeated by one individual.

5. The examiner and the recorder working at any station were both trained in performing either function. This reduced the fatigue and monotony resulting from one activity.

6. Examinations were scheduled in small groups, thus reducing the psychological pressure of the measuring process.

Through these foregoing steps, an attempt was made to minimize the known sources of technical and personal errors.

SUBJECTS

While the technical features of the study were being developed, plans were made for the actual measurement in the field. In order to fulfill the needs of the study, a total of some 1500 subjects were required. A letter was sent to the administrative officials of a group of eastern colleges. A short description of the purpose of the study was outlined and in the return letter a space was provided for general approval.

The data in the present study have been obtained from the measurements of men and women students in ten colleges and universities in southeastern Pennsylvania and northern Delaware.

The total records of over 1500 students were reduced to a final group of 1200 students. These were divided into eight groups so as to include exactly 150 subjects of each sex for each age group, eighteen to twenty-one.

Measurements of each subject included standing height, weight, kneeling height, sitting height, span, bi-deltoid width, and bi-iliac width. From these seven individual measurements, anthropometric ratios for each subject were computed in the case of height-weight, standing height-kneeling height, standing height-sitting height, standing height-span, bi-deltoid width-bi-iliac width, and span-bi-deltoid width. In each ratio, the first measure listed serves as the denominator of the fraction for computation purposes. All indices were determined through the use of an electric calculator.

TREATMENT OF THE DATA

Through statistical procedures, the means, standard error of the means, sigmas, and estimated parameter values for each of the eight groups were determined. At this point, each of the eight samples possessed certain statistics which were descriptive of the seven anthropometrical measurements and the six indices of each group. These mean values with their standard errors are listed in Table 1 and Table 2. Using the standard error of the difference between two means as the denominator of the fraction and the actual difference as the numerator, a critical ratio component was evolved. This critical ratio was compared with the .01 level of significance (2.58 sigma) as an arbitrary standard.

TABLE 1

*Summary of the mean anthropometrical measurements and ratios of college women aged 18 to 21**

MEASURE OR RATIO	AGE GROUPS			
	18	19	20	21
Weight (kgms.)	56.88 ± .57	56.60 ± .65	56.83 ± .69	56.03 ± .57
Standing Height	162.86 ± .45	162.80 ± .49	163.08 ± .51	164.20 ± .48
Kneeling Height	122.28 ± .31	122.29 ± .35	122.56 ± .37	122.99 ± .34
Sitting Height	85.40 ± .23	85.29 ± .26	85.76 ± .24	86.14 ± .29
Span	164.16 ± .59	163.74 ± .57	163.82 ± .64	164.38 ± .59
Bi-Deltoid	38.95 ± .17	38.44 ± .17	38.86 ± .20	38.59 ± .15
Bi-Iliac	29.01 ± .19	28.77 ± .21	29.23 ± .19	29.36 ± .15
Standing Height-Weight	.3513 ± .0031	.3461 ± .0033	.3460 ± .0037	.3403 ± .0032
Standing Height-Kneeling Ht.	.7513 ± .0006	.7516 ± .0006	.7513 ± .0006	.7491 ± .0006
Standing Height-Sitting Ht.	.5241 ± .0011	.5245 ± .0012	.5254 ± .0009	.5240 ± .0010
Standing Height-Span	1.0081 ± .0021	1.0063 ± .0017	1.0058 ± .0017	1.0021 ± .0019
Bi-Deltoid-Bi-Iliac	.7463 ± .0037	.7480 ± .0046	.7521 ± .0040	.7619 ± .0033
Span-Bi-Deltoid	.2370 ± .0011	.2351 ± .0010	.2368 ± .0011	.2345 ± .0009

* The standard error of each mean is given after the ± sign.

TABLE 2

*Summary of the mean anthropometrical measurements and ratios of college men aged 18 to 21**

MEASURE OR RATIO	AGE GROUPS			
	18	19	20	21
Weight (kgms.)	71.07 ± .82	71.70 ± .75	71.93 ± .73	74.43 ± .82
Standing Height	176.98 ± .56	176.66 ± .56	177.00 ± .51	178.28 ± .52
Kneeling Height	131.80 ± .40	131.75 ± .39	131.83 ± .37	132.93 ± .34
Sitting Height	91.00 ± .29	91.00 ± .29	91.09 ± .28	91.60 ± .19
Span	181.46 ± .66	180.74 ± .62	181.16 ± .60	182.76 ± .57
Bi-Deltoid	44.25 ± .22	44.19 ± .17	44.54 ± .19	45.21 ± .20
Bi-Iliac	31.05 ± .18	30.91 ± .16	31.31 ± .16	31.82 ± .18
Standing Height-Weight	.4013 ± .0041	.4049 ± .0035	.4060 ± .0036	.4163 ± .0040
Standing Height-Kneeling Height	.7452 ± .0006	.7458 ± .0006	.7444 ± .0006	.7446 ± .0006
Standing Height-Sitting Height	.5150 ± .0011	.5150 ± .0010	.5130 ± .0011	.5132 ± .0013
Standing Height-Span	1.0269 ± .0021	1.0231 ± .0019	1.0241 ± .0019	1.0236 ± .0020
Bi-Deltoid-Bi-Iliac	.7037 ± .0033	.7012 ± .0034	.7028 ± .0034	.7036 ± .0035
Span-Bi Deltoid	.2438 ± .0012	.2444 ± .0010	.2457 ± .0010	.2474 ± .0012

* The standard error of each mean is given after the ± sign.

The significance of the differences between each measure and ratio among the sexes as a group was obtained. A further comparison was made of male and female groups in the same age category with respect to the differences between their means for each measure and ratio.

Findings

The principal intra-sex and inter-sex findings of the present study follow:

INTRA-SEX DIFFERENCES

Measurements. 1. In the case of mean weights of college men, a significant difference between the 18-year olds and the 21-year olds is indicated by a critical ratio of 2.90. All other comparisons between the different age groups produced no critical ratio sufficiently large enough to indicate a significant difference. On the other hand, all comparisons between the means of the women's groups show no significant differences as based upon obtained critical ratios.

2. In the case of all heights of college men, no significant differences were indicated when comparisons were made between the four age groups. The same was also evident in the case of the women when comparisons were made between each group.

3. As far as arm reach was concerned, there were no significant differences within either sex when their age groups were compared.

4. In the case of both bi-deltoid and bi-iliac widths of college men, the only significant differences were indicated first, between the 18-year-olds and the 21-year-olds and second, between the 19-year-olds and the 21-year-olds. In each of the preceding comparisons, a critical ratio of greater than 3.00 was obtained. For the women, there were no comparisons that produced a critical ratio indicating significant differences between any of the groups.

Ratios. 1. In the case of the college men, there were no significant differences between the means of each age group when they were compared with respect to each of the six indices.

2. When the means of the college women at each age level were compared for significant differences, similar results, with one exception, were obtained. It was found that the mean differences in the bi-deltoid-bi-iliac width of 18-year-olds and 21-year-olds produced a critical ratio of 3.12. From this, it may be inferred that these two groups are significantly different with regard to this ratio.

INTER-SEX DIFFERENCES

In every comparison, the college men and the college women differ significantly at each age level. These differences are much more marked than those exhibited within the same sex.

For comparative purposes, these differences are best shown by examining

the ratio between the men and women at each of the four age levels with regard to first, the measurements and second, the indices.

Measurements. When the ratios are presented in an increasing series, they result in the following arrangement: sitting height, kneeling height, bi-iliac width, standing height, span, bi-deltoid width, and weight.

Between the sexes, the ratios of three measures—standing height, span, and sitting height—remain constant during the age period under consideration. The ratios relating to bi-iliac width and kneeling height, while relatively constant, show a slight decrease at the 21-year level. The index for bi-deltoid width decreases markedly during this four year span, as does the index between the sexes for weight.

Thus, it is apparent that the differences between college men and women at these age levels are least as regards sitting height, kneeling height, and bi-iliac width, and greatest as regards standing height, span, bi-deltoid width, and weight.

The very fact that women, who are generally smaller than men, come closest to men in sitting height and pelvic width is a clear demonstration of the more significant specialization of the trunk and pelvis for reproductive purposes.

Ratios. In turning from a comparison of the means to a comparison of the ratios, similar trends are again observed.

It is readily observed that three of these ratios for the women are proportionately greater than the same three indices for the men. When presented in an increasing series, the following arrangement results—standing height-kneeling height; standing height-sitting height; and bi-deltoid width-bi-iliac width. Of these three, only in the last of these does a greater increase occur as the women approach the age of 21.

In the remaining three ratios, those pertaining to the men are greater than those for the women. Arranged in an increasing series, these ratios are standing height-span; span-bi-deltoid width; and standing height-weight. The second and third of these indices increase further as the men approach the age of 21.

Thus, it will be seen that differences in the anthropometric ratios between men and women at these age levels are least as regards standing height-kneeling height; standing height-sitting height; and standing height-span. Chronologically also, the differences between men and women remain relatively the same in the case of these indices.

It is also apparent that differences in the anthropometric ratios between men and women students are greatest as regards span-bi-deltoid width; bi-deltoid width-bi-iliac width; and standing height-weight. During the age span under consideration, the differences in these three ratios increase progressively with advancing age.

Considering the data as a whole, especially as regards linear dimensions, it may be seen that the male's greater total stature is more particularly a matter of greater length of legs. Thus, the approximate mean difference between men and women in standing height, kneeling height, and sitting

height are, respectively 14 centimeters, nine centimeters, and five centimeters.

What this means is that in comparison with the average female, the average male shows a relative loss in stature of six centimeters when he is kneeling. When he assumes a sitting position, a further approximate reduction of four centimeters occurs in his relative stature. It may be further deduced from this that the lower segment of the leg increases the male's height proportionately more than the upper segment of the leg.

The standing height-kneeling height and the standing height-sitting height ratios of each sex call attention to the greater proportional sitting height and kneeling height of the female students.

Biologically, it would appear that the female's relatively greater trunk length must be of considerable importance. This presents an interesting problem with respect to the relative trunk length of short students and of tall students. Since the data for women revealed that differences in total stature between the various groups were insignificant, the data cards of the 30 shortest and the 30 tallest women were selected from the total 600 subjects for comparison. Thus, each group selected represented the lower 5% and the upper 5%, respectively, as to stature.

The mean standing height-sitting height index of the short women is .5327, with a standard mean error .0022 and a standard deviation of .0118. The mean of the same index for tall women is .5115, with a standard mean error of .0022 and a standard deviation of .0116. In the test for reliability of the difference between these means, the obtained critical ratio is high and significant. Thus, it is quite evident that the short women have a relatively greater trunk length than the tall women.

The same procedure was adopted with respect to the data for 30 of the tallest men and 30 of the shortest men. The mean standing height-sitting height index of the short man is .5192, with a standard mean error of .0023 and a standard deviation of .0122. The mean of the same index for the tall men is .5075, with a standard mean error of .0021 and a standard deviation of .0112. In testing for the reliability of the difference between these means, the obtained critical ratio is only one-half as great as that obtained in the case of the tall and short women.

Thus, even though both short men and short women have greater relative sitting heights than the tall students of their respective sexes, the short women show a significantly greater proportional difference in this measure than the short men.

Relation to Earlier Studies

A review of the early literature on anthropometry has furnished means for a multitude of measures. But, with few exceptions, measures of variability do not accompany these averages.

In the anthropometrical manual of Amherst College, published in 1887 by Hitchcock (3) and Seelye (16) certain typical means of 1254 college men are listed according to age:

MEASURE	AGE			
	18	19	20	21
Weight (kg)	59.4	61.0	61.8	63.2
Height (cm)	172.2	172.1	172.1	172.5
Sitting Height (cm)	89.7	90.3	90.4	91.0
Shoulder Breath (cm)	42.2	42.8	43.1	43.7
Stretch of Arms (Span) (cm)	178.0	178.0	178.1	177.8

Where attention has been given to specific age groups, these figures approximate those of other investigators. The means of the college men in the present study may be compared with those above and it becomes quite evident that contemporary college men are decidedly larger with respect to these measurements.

In the case of the women, statistics gathered by Hitchcock (17) from the measurements of 1000 Mount Holyoke and Wellesley students showed averages for all age levels consistently less than those reported in the present study.

If the listed means of these earlier studies, which are unaccompanied by measures of variability, are accepted as reliable, then it may be concluded that the college men and women of the present study are decidedly larger with respect to these measurements than those students previously reported in early studies.

Since many of the recent college studies have not been concerned with anthropometric measurements at specific college age levels for each sex, it is rather difficult to make valid comparisons with the results of the present study. However, where attention has been given in part to such age levels, the results are fairly consistent with the ones obtained and reported in the present study.

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Bowling Norms and Learning Curves for College Women

MARJORIE PHILLIPS AND DEAN SUMMERS
School of Health, Physical Education, and Recreation
Indiana University

THE GENERAL purpose of this study was to develop bowling norms and analyze learning curves in bowling for college women.

Specifically, there were two questions to be answered. (a) Is there a need in regular college classes for norms at different levels of ability. (b) Is there a difference in the character of the learning at the different levels of ability.

Procedure

A letter was sent to the women's physical education departments in 117 colleges and universities, including state universities in each of the 48 states, and all schools listed as having participated in the National Intercollegiate Telegraphic Bowling meet. The letter explained the purpose of the study and sought to enlist the cooperation of those schools that taught bowling in regularly scheduled physical education classes. A self-addressed penny post card was enclosed in the letter to facilitate replies. Answers were received from 79 schools and of these 28 indicated that bowling was taught as part of the physical education program. All 28 of the schools with regularly scheduled bowling classes indicated their willingness to participate in the study.

An information sheet, including directions for recording scores, and recording sheets were sent to these schools and returns were received from 26 of them.[1] Only scores for completed lines were included on the scoring sheets. Usable scores were received from 22 schools with a total of 3634 students who had completed from 10 to 25 lines. For various reasons, scores from four of the schools were not usable.

The instructors of the classes had been asked to classify students' ability according to criteria of bowling experience and amount of instruction. It was found that this method of classification did not differentiate between the bowlers' ability as judged by their scores. It was decided to disregard the amount of experience and instruction and classify students by their scores only. Since bowling scores are known to fluctuate considerably from line to line, it was thought that an average of several scores would be a better classifier than a single score. The average of the first five lines bowled

[1] See Appendix for list of participating schools.

was finally selected as the criterion for classifying students according to ability. This average was found for each of the 3634 students.[2]

A previous unpublished study conducted at Indiana University had indicated that when students were classified according to their beginning average, satisfactory norms could be set up at 10 point intervals. This procedure was followed in the present study. Scores for all students were regrouped on new recording sheets. Thus in the new grouping all students whose first five game average was between 50–59.9 were considered as one ability level, those whose average was between 60–69.9 were a second ability level, and so on for every 10 points difference. Learning curves were constructed and norms set up for each of the ability levels.

TABLE 1

Organization of women's bowling classes at 22 colleges

	NO. OF BOWLERS PER CLASS	NO. OF BOWLERS PER ALLEY	NO. OF LINES PER PERIOD	NO. OF PERIODS PER SEASON
Median	23	4	1	20
Range	10–40	2–6	1–3	6–45

Certain problems were presented because of the fact that the number of lines bowled per student varied from college to college. Many of the colleges reported only 10 lines for each student while others reported varying numbers up to 25.

In order to satisfy the needs of the different colleges, norms were established at each level of ability, at the end of 10 lines of bowling, and for five line intervals up to 25 lines of bowling. Norms for the first 10 lines are based on a cumulative average, for succeeding five line intervals, the average of each five lines was used.

A distance of 1.2 standard deviation was used to separate the qualitative ratings of inferior, poor, average, good, and superior. Thus an individual rated as "inferior" would have a score at least 1.8 standard deviation below the mean score at her level of ability, or a person rated as "average" would have a score somewhere between .6 standard deviation below the mean to .6 standard deviation above the mean.

Results

An analysis of the information sheets revealed that college women's bowling classes are being taught under a variety of conditions. Table 1 summarizes the various organizations of bowling classes.

It was found that six colleges teach pin bowling, six teach spot bowling, and nine teach both pin and spot bowling. Fifteen colleges teach the straight ball delivery, seven teach both the straight and hook ball, and

[2] Grateful acknowledgment is made to the graduate students who assisted in the reorganization of scores.

none teach the curve ball. Six colleges own their alleys, while 16 use public alleys. In order to provide some evidence as to the effect on learning of the various organizations of classes, two groups with 48 bowlers in each, were paired on the basis of their beginning averages.

The girls in Group One met in classes which bowled twice a week for 14 weeks. There were 30 girls in the class, with five girls on each alley and they bowled one line at each class meeting. The bowlers in Group Two were in classes which met twice a week for seven weeks. There were 18 girls in these classes, with three girls on each alley, and they bowled two lines at each class meeting. The standard error of the difference between the means of the two groups at the end of the 28 lines was found by the formula for related groups. The critical ratio was 1.36, indicating that the obtained difference could occur by chance approximately 17 times in 100. While this is far from conclusive evidence on the effect of various learning situations it does indicate that those conditions examined were not producing a significant difference in bowling skill.

Learning curves at the various levels of ability are graphically represented in Figure I. The most noticeable difference in the curves is one that would reasonably be anticipated, that is, in the initial rise. The initial rise is greatest at the lowest skill and gradually decreases as the skill level increases. This could be expected since the possibilities for improvement are greater at the lower skill levels. Thus the amount of improvement to be expected will differ considerably with the level of skill.

Another difference which becomes apparent on examining the curves is in the amount of fluctuation at the various skill levels. These fluctuations can probably be attributed in part to the fact that smaller numbers of people were used in constructing the curves at the extreme skill levels with the greatest numbers of people being available at the middle levels. Also there are fewer people concerned in all the curves as the number of lines increases. The effect of N can be reduced by comparing the curves in which N is approximately the same. N is approximately the same at the 50 and 120 levels, at the 60 and 110 levels, at the 70 and 100 levels, and at the 80 and 90 levels. In all but the 80 and 90 levels, which are very nearly alike, it can be seen that the fluctuations appear more often and are greater at the high-skill levels than at the low-skill levels.

Further examination of the curves reveals that starting with the 80–89.9 level and continuing in each of the higher levels, the first decline in the curve appears at the fifth or sixth line, the fall becoming more marked as the skill level increases. The reason for this is not readily apparent, but instructors who are aware of it may be prepared to give additional guidance and motivation at this stage of learning.

In no instance do the learning curves overlap each other, which might be interpreted as evidence that the method of classification used is an effective one. More convincing evidence on this point is provided by examining the differences between the means of the final five game averages for adjacent skill levels. A summary of these data is given in Table 2.

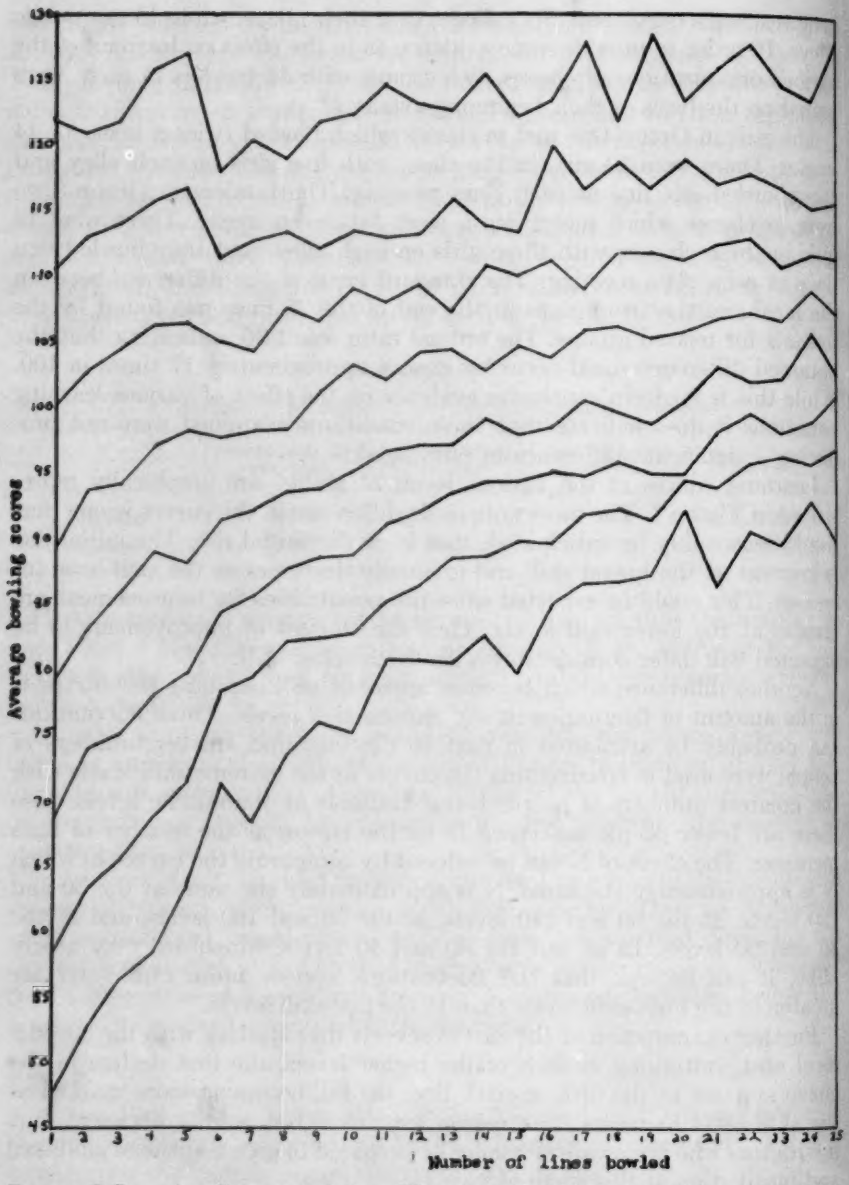

FIGURE I. Learning Curves of College Women at Various Levels of Bowling Ability

The difference between the means of the adjacent skill levels is significant at better than the 1% level of confidence in every instance except between the 50–59.9 and 60–69.9 levels. This can be accepted as reasonable proof that the groups are from different populations as regards bowling skill at

the end of 25 lines of bowling instruction, and that norms are desirable for each skill level.

Norms at the different levels of ability and directions for using them appear in Appendix A.

The greatest weakness of this study is the fact that insufficient numbers of cases have been used in constructing norms at the extreme levels of ability and in many instances beyond 10 lines of bowling; also the norms are heavily weighted by scores from Indiana University (approximately 38%).[3]

Another weakness arises out of the fact that the conditions under which bowling is taught are varied and that students will have done different amounts of bowling out of class. In spite of these weaknesses, however, the norms can prove very useful in motivating the student and allowing her

TABLE 2

Critical ratio of difference between means of adjacent skill levels at the end of 25 lines of bowling

SKILL LEVEL	N	M	S D	S E_M	C.R.	LEVEL OF CONFIDENCE
50–59.9	40	91.1	11.7	1.85	1.76	7.84%
60–69.9	114	94.8	10.7	1.002	3.6	beyond .26%
70–79.9	213	99.7	13.1	.89	2.69	.72%
80–89.9	249	102.8	11.7	.74	4.7	beyond .26%
90–99.9	255	107.8	12.2	.76	3.8	beyond .26%
100–109.9	200	112.1	11.6	.82	3.1	beyond .26%
110–119.9	119	116.3	11.8	1.08	4.6	beyond .26%
120–129.9	50	126.0	12.8	1.81		

to know her comparative progress. In addition, the norms and learning curves should provide information for the teacher which will assist her materially in guiding her students.

Summary and Conclusions

The general purpose of this study was to develop bowling norms and analyze learning curves for college women. Bowling scores were collected for 3634 students from 22 colleges and universities. Norms and curves based on these data were developed.

There is a need for norms at different levels of bowling ability. After 25 lines bowled during class instructional periods, the ability groups were significantly different from each other in regard to bowling skill.

There are differences in the character of the learning at the different levels of ability. The initial rise in the learning curve is much more pronounced at the lower skill levels, decreasing progressively as the skill level

[3] It is hoped that college teachers of bowling for women will continue to send scores to the authors, particularly scores for those students who have bowled 25 lines in class. Norms will be revised at a future date if scores are received.

increases. Fluctuations in the curve appear more frequently and are more pronounced at the high skill levels than at the low. Starting with one of the middle skill levels and becoming progressively more pronounced as skill increases, a decline in the curve appears at the fifth or sixth line.

There is some evidence to show that varied organizations of classes do not produce a significant difference in the degree of skill attained.

The main weakness of the study is an insufficient number of cases in constructing some of the norms.

Appendix A

BOWLING NORMS FOR COLLEGE WOMEN

Level of ability, 50–59.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 21–25
Superior	75 and up	102 and up	109 and up	113 and up
Good	69–74	89–101	96–108	99–112
Average	61–68	75–88	81–95	84–98
Poor	55–65	62–74	67–80	70–83
Inferior	54 and below	61 and below	66 and below	69 and below
N	99	64	59	40
M	64.5	81.4	87.8	90.1
S.D.	5.1	10.7	11.5	11.7

Level of ability, 60–69.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 21–25
Superior	85 and up	109 and up	114 and up	115 and up
Good	78–84	96–108	100–113	102–114
Average	70–77	81–95	85–99	88–101
Poor	63–69	68–80	71–84	76–87
Inferior	62 and below	67 and below	70 and below	75 and below
N	322	206	151	114
M	73.5	88.0	92.2	94.8
S.D.	6.0	11.3	11.6	10.7

Level of ability, 70–79.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 21–25
Superior	93 and up	117 and up	118 and up	124 and up
Good	86–92	101–116	103–117	109–123
Average	78–85	85–100	88–102	92–108
Poor	71–77	70–84	74–87	76–91
Inferior	70 and below	69 and below	73 and below	75 and below
N	611	378	280	213
M	81.3	92.7	95.2	99.7
S.D.	5.7	12.7	12.0	13.1

Level of ability, 80–89.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 20–25
Superior	101 and up	119 and up	120 and up	125 and up
Good	94–100	106–118	106–119	111–124
Average	86–93	91–105	91–105	96–110
Poor	79–85	78–90	77–90	82–95
Inferior	78 and below	77 and below	76 and below	81 and below
N	818	492	337	249
M	89.3	97.8	98.2	102.8
S.D.	5.8	11.1	11.6	11.7

Level of ability, 90–99.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 21–25
Superior	110 and up	126 and up	127 and up	131 and up
Good	102–109	111–125	112–126	116–130
Average	93–101	96–110	97–111	100–115
Poor	86–92	82–95	82–96	86–99
Inferior	85 and below	81 and below	81 and below	85 and below
N	797	502	342	255
M	97.2	103.4	104.2	107.8
S.D.	6.5	11.8	12.1	12.2

Level of ability, 100–109.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 21–25
Superior	117 and up	130 and up	134 and up	134 and up
Good	110–116	117–129	119–133	120–133
Average	102–109	103–116	104–118	105–119
Poor	95–101	89–102	90–103	91–104
Inferior	94 and below	88 and below	89 and below	90 and below
N	552	369	247	200
M	105.6	109.1	111.1	112.1
S.D.	6.0	11	11.9	11.6

Level of ability, 110–119.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 21–25
Superior	125 and up	135 and up	139 and up	139 and up
Good	118–124	122–134	125–138	124–138
Average	110–117	107–121	110–124	109–123
Poor	103–109	94–106	96–109	95–108
Inferior	102 and below	93 and below	95 and below	94 and below
N	310	209	153	119
M	113.6	114.1	116.8	116.3
S.D.	5.8	11.2	11.8	11.8

Level of ability, 120–129.9

RATING	LINES 1–10	LINES 11–15	LINES 16–20	LINES 21–25
Superior	135 and up	145 and up	146 and up	150 and up
Good	127–134	132–144	133–145	135–149
Average	118–126	117–131	120–132	118–134
Poor	110–117	104–116	107–119	103–117
Inferior	109 and below	103 and below	106 and below	102 and below
N	125	93	60	50
M	122.4	124.0	126.0	126.0
S.D.	6.6	11.0	10.4	12.8

DIRECTIONS FOR USING NORMS

1. Find bowler's beginning level of ability, by averaging her first five lines bowled.
2. Find her rating at the end of 10 lines by averaging her first 10 lines bowled, and referring to the norms at her level of ability.
3. Find her rating at the end of 15 lines by averaging lines 11 through 15, and referring to the norms at her level of ability. Follow this same procedure for her rating at the end of 20, and 25 lines; only averaging lines 16 through 20, and 21 through 25.

SAMPLE OF HOW TO USE NORMS

Scores made by a student on 25 successive lines of class bowling.

54 65 58 62 78 80 112 74 93 97 83 99 94 77 95 69 108 115 118 110 121 107 95 116 123

1. Mean of first five lines bowled is 63.4, therefore the student's level of ability is 60–69.9.
2. Mean of the first 10 lines bowled is 77.3, student's rating at end of 10 lines is "average".
3. Mean of lines 11 through 15 is 89.6, student's rating at end of 15 lines is "average".
4. Mean of lines 16 through 20 is 104.0, student's rating at end of 20 lines is "good".
5. Mean of lines 21 through 25 is 112.4, student's rating at end of 25 lines is "good".

Appendix B

NAMES OF SCHOOLS WHOSE SCORES WERE USED IN THE STUDY

Bethany College, Bethany, West Virginia
Drexel Institute of Technology, Philadelphia, Pennsylvania
Duke University, Durham, North Carolina
Heidelberg College, Tiffin, Ohio
Indiana University, Bloomington, Indiana
MacMurray College, Jacksonville, Illinois
Michigan State College, East Lansing, Michigan
Michigan State Normal College, Ypsilanti, Michigan

Montana State University, Missoula, Montana
Ohio Wesleyan University, Delaware, Ohio
Purdue University, Lafayette, Indiana
St. Olaf College, Northfield, Minnesota
Stephens College, Columbia, Missouri
University of California at Los Angeles, Los Angeles, California
University of Kentucky, Lexington, Kentucky
University of Illinois, Urbana, Illinois
University of Iowa, Iowa City, Iowa
University of Nevada, Reno, Nevada
University of Southern California, Los Angeles, California
University of Wisconsin, Madison, Wisconsin
Vassar College, Poughkeepsie, New York
Washington State College, Pullman, Washington

A Study of Boxing in Selected Colleges and Universities[1]

WILLIAM E. HARLAN
College of Physical Education, Health, and Athletics
University of Florida
Gainesville, Florida

ONE OF the most controversial issues in physical education in the colleges and universities throughout the United States during the past decade has been the sponsoring of boxing. As a college activity, boxing has been popular with spectators and participants alike. Intercollegiate boxing has gained support each year since World War II with 16 intercollegiate teams in 1946 (4), 39 teams in 1947 (5), and 47 teams in 1948 (6).

Much has been said concerning both the negative and positive aspects of boxing. It is the problem of the staff responsible for the development of a program of physical education to examine carefully the values and hazards of this sport, which from its infancy has been a part of the program of certain institutions of higher learning. If boxing has received undeserved notoriety, this should be recognized. This normative survey provides information for those persons in institutions of higher learning responsible for the boxing program which will assist them in analyzing and solving the problems related to boxing.

Review of the Literature

In 1940, Kenney, Thacker, and Gebhart (2) reported on a study evaluating boxing as a college activity. Questionnaires were sent to outstanding neurologists and psychiatrists, pathologists and coroners of the larger towns, and athletic directors and health service directors of the larger colleges and universities. In summarizing the results of questions asked the neurologists and psychiatrists; the authors made this statement:

> In some respects the facts given in this table do not bear directly on the question of the study, since the experience of these doctors was gained from boxers of all kinds, professional as well as amateurs, and undoubtedly most of their cases are not resultant from college boxing directly.

For the reason stated, the authors have been attacked by some proponents of college boxing.

[1]An abstract of a thesis presented to the Graduate Council of the University of Florida in partial fulfillment of the requirements for the degree of Master of Arts in Education, September, 1949.

The conclusions of this study were that boxing should not be included in the sports program of an educational institution, either as a curricular or an extra-curricular activity. This conclusion was based on the following findings:

1. The objective of all offensive maneuvers in boxing is to injure an opponent. The more efficiently an offensive is executed, the greater the injury incurred.
2. The type of injuries most common are insidious in nature and in many cases are not recognized by either participants or coaches. The effects of head blows are cumulative and are not recognized in early stages. Knockouts are not recorded as injuries in this sport.
3. Contests of intramural or intercollegiate nature are impossible to control, hence the dangers of ill effects to participants outweigh the values of competition.
4. Instructional classes in boxing are not particularly dangerous, but it is impossible to justify teaching an activity and at the same time to advise students against participation in the activity taught.

Steinhaus (8), in discussing forms of exercise which may bring harm to the body, points out that only in boxing is there systematic and deliberate intent to inflict injury on the opponent.

In 1945, Franz Schuck, M.D. (7) of the Federal Security Agency, Committee on Physical Fitness, reported on brain injuries in boxing. In this report the following statement appeared to be significant:

> . . . for it may well be that the educational profession has been alarmed by a newly discovered pathological picture which stems from a different field: from professional boxing and its long known vocational dangers.

Schuck recommended the use of headgears and a well-padded floor for the avoidance of accidents. The report concludes with the observation: "With these precautions, school boxing seems sufficiently safe from the medical point of view."

In an article by Colonel Harvey L. Miller (3), a man with 45 years association with boxing, the record of collegiate boxing fatalities, for the years 1937 to 1947 inclusive, is pointed out. Among 49,280 participants in bouts there were three deaths, or one fatality for each 16,000 participants. In order to avoid any fatalities and to secure the values inherent in boxing, Miller recommends that competent coaching be provided and careful control be exercised in administering a worthwhile boxing program.

Haislet (1) in discussing the frequent objections to boxing, points out that these objections are caused by confused ideas as to what boxing is. This author comments:

> To the few who know and understand boxing as an activity divorced from the environment with which it is always associated, boxing has much to offer in the way of all around development. It has a place in the education of every youth.

Haislet concludes by pointing out that leadership, correct teaching methods, and good supervision are needed in the conduct of boxing for educational outcomes.

Limitation of the Study

This study is limited to a survey of boxing in four-year colleges and universities which sponsor programs of physical education, which are geographically located within the boundaries of the Southern and Southeastern Conferences, and which register male students.

Source of Data

To gather data for this study, the writer prepared a questionnaire and sent it to athletic directors of institutions of higher learning. The questionnaire was divided into four sections: General Information, with

TABLE 1

Status of boxing in colleges and universities in the geographical limits of the Southern and Southeastern Conferences, 1948–1949

ENROLMENT	CLASSIFICATION BY ENROLMENT	INCLUDE BOXING		DO NOT INCLUDE BOXING	
	No.	No.	Per cent	No.	Per cent
0–999	25	8	32	17	68
1000–1999	9	6	67	3	33
2000–2999	3	3	100	0	0
3000–3999	4	1	25	3	75
4000–4999	1	1	100	0	0
5000–5999	4	2	50	2	50
6000–6999	2	2	100	0	0
7000–7999	1	1	100	0	0
8000–8999	2	2	100	0	0
Not reporting	7	3	43	4	57
Totals	58	29	50	29	50

4 questions; Required Physical Education, with 28 questions; Intramural Program, with 33 questions; and the Intercollegiate Program, with 26 questions. A letter of transmittal was sent to explain the study and to encourage response. One hundred and nine institutions were sent a questionnaire with 58 replying which placed certain limitations on the study (Appendix A). The fact that an appreciable number of colleges and universities are considering the addition or the return of boxing to their programs placed a limitation on the replies from these institutions.

Treatment of Data

The status of boxing in 58 colleges and universities is tabulated in Table 1 to show the classification by enrolment of those which include boxing and those that do not have boxing.

A study of this table reveals the following:

1. Enrolment does not seem to be a factor in determining whether or not a college or university includes boxing as a part of the program.
2. Five of the enrolment classifications used in this study (involving nine institutions) show 100% participation in boxing.
3. Twenty-nine institutions, or 50%, included boxing in their programs.

Of the colleges and universities indicating that boxing was a part of the program, this activity appeared in one or more of three phases of the program: the required physical education program; the intramural program; and the intercollegiate program. The type of programs including boxing and classified by institutional enrolment is shown in Table 2.

TABLE 2

Type of boxing programs in colleges and universities in the geographical limits of the Southern and Southeastern Conferences, 1948–1949

ENROLMENT	REQUIRED PROGRAM		INTRAMURAL PROGRAM		INTERCOLLEGIATE PROGRAM		TOTAL
	No.	Per cent	No.	Per cent	No.	Per cent	No.
0–999	8	100	1	13	2	25	8
1000–1999	4	67	3	50	1	17	6
2000–2999	3	100	2	67	1	33	3
3000–3999	1	100	1	100	1	100	1
4000–4999	0	0	1	100	0	0	1
5000–5999	1	50	2	100	0	0	2
6000–6999	2	100	2	100	1	50	2
7000–7999	1	100	0	0	1	100	1
8000–8999	2	100	1	50	1	50	2
Not Reporting	2	67	1	50	1	33	3
Totals	24	83	14	48	9	31	29

Note: Several colleges and universities include boxing in more than one phase of the program which accounts for the overlapping in percentages.

Twenty-four institutions, or 83% of those institutions reporting boxing as an activity, included boxing in the required physical education programs. Fourteen institutions, or 48%, offered boxing as an intramural activity, and nine institutions, or 31%, reported intercollegiate boxing programs.

Two questions were asked to determine the opinions of athletic directors concerning boxing. This information is revealed in Table 3.

The athletic directors expressed opinions for and against boxing, with 40% stating that this activity should be included, and 36% stating that it should not be included. Fourteen athletic directors, or 24%, failed to express an opinion.

The opinions for the second question show a greater difference than the first, with 47% indicating that injury of an opponent was not the objective

of boxing, and 31% stating that it was. Thirteen athletic directors, or 22%, failed to express an opinion.

Summary

The data reveal the following significant facts:

1. One-half of the institutions included boxing in one or more phases of their programs.
2. The greatest percentage of those including boxing, offered this activity in the required physical education programs.
3. Just less than one-half included boxing in the intramural program.
4. The lowest percent of inclusion was in the intercollegiate program.
5. Several institutions which did not sponsor intramural or intercollegiate boxing reported plans to include this activity in the future.

TABLE 3

Attitudes of Athletic Directors in Colleges and Universities Concerning Boxing

QUESTION	YES	PER CENT	NO	PER CENT	NOT REPORTING	
					No.	Per cent
1. Do you feel that the positive aspects of boxing outweigh the negative aspects significantly enough to warrant its inclusion as an activity in institutions of higher learning?	23	40	21	36	14	24
2. Do you feel that boxing, *as usually taught*, has as its prime objective the injury of an opponent?	18	31	27	47	13	22

6. Size of enrolment did not seem to influence the inclusion or exclusion of boxing in the program.
7. More of the athletic directors were of the opinion that boxing should be included in institutions of higher learning than were of the opinion that it should not be included as an activity.
8. A majority of athletic directors were of the opinion that injury of the opponent was not the prime objective of boxing, *as usually taught*.
9. Injury risk was the most frequently mentioned reason for not including intramural or intercollegiate boxing in the institutions surveyed in this study.
10. Where boxing is conducted, those authorities responsible for the program are in favor of this activity.

Conclusions

1. The institutions of higher learning included in this study are about evenly divided with respect to including or not including boxing as an activity in the program.

2. Boxing in the required physical education program is more generally accepted than intramural and intercollegiate boxing activity.

Recommendations

1. A study should be made of the nature and extent of injuries incurred in boxing activity sponsored by institutions of higher learning as compared with injuries in other sports.

2. A study should be made to determine, if possible, the difference between boxing as conducted in colleges and universities, and boxing as a professional sport.

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APPENDIX A

List of colleges and universities to which the questionnaire was submitted

ALABAMA

* Alabama Polytechnic Institute
* Alabama State Teachers College (Troy)
University of Alabama
* Birmingham-Southern College
* Howard College
* Spring Hill College

DISTRICT OF COLUMBIA

* American University
* Catholic University of America
Gallaudet College
George Washington University
Georgetown University

FLORIDA

* Florida Southern College
* Florida State University
* University of Florida
* John B. Stetson University
* University of Miami
Rollins College
* University of Tampa

* Asterisk indicates those colleges and universities responding to the questionnaire.

GEORGIA

Emory University
* Georgia School of Technology
* University of Georgia
* Mercer University
North Georgia College
Piedmont College

KENTUCKY

Berea College
Centre College of Kentucky
* Kentucky (Eastern) State College
* Georgetown College
* University of Kentucky
Kentucky Wesleyan College
* University of Louisville
Kentucky (Morehead) State College
Kentucky (Murray) State College
Kentucky (Western) State College
Transylvania College
Union College

LOUISIANA

Centenary College of Louisiana
Louisiana College
* Louisiana Polytechnic Institute
* Louisiana State University and Agricultural and Mechanical College
Loyola University of the South
Southeastern Louisiana College
* Southeastern Louisiana Institute
* Tulane University of Louisiana
Northwestern State College of Louisiana

MARYLAND

* Johns Hopkins University
Loyola College
* Maryland State Teachers College (Towson)
* University of Maryland
* United States Naval Academy
Washington College
Western Maryland College

MISSISSIPPI

Mississippi Delta State Teachers College
Millsaps College
* Mississippi College
Mississippi State College
University of Mississippi
Mississippi Southern College

NORTH CAROLINA

North Carolina (Appalachian) State Teachers College
Atlantic Christian College

* Catawba College
* Davidson College
* Duke University
* North Carolina (East) Teachers College
* Elon College
* Guilford College
* High Point College
* Lenoir-Rhyne College
* North Carolina State College of Agriculture and Engineering
* University of North Carolina
* Wake Forest College

SOUTH CAROLINA

College of Charleston
* The Citadel
* Clemson Agricultural College
* Erskine College
* Furman University
Newberry College
Presbyterian College
* University of South Carolina
Wofford College

TENNESSEE

* Carson-Newman College
University of Chattanooga
* Cumberland University
* King College
Lambuth College
Lincoln Memorial University
Maryville College
* Memphis State College
Middle Tennessee State College
Milligan College
University of the South
* Southwestern College
* Tennessee Polytechnic Institute
University of Tennessee
Tusculum College
Union University
* Vanderbilt University

VIRGINIA

Bridgewater College
Emory and Henry College
Hampden-Sidney College
* Lynchburg College
Randolph Macon College for Men
* University of Richmond
Roanoke College
* Virginia Military Institute
* Virginia Polytechnic Institute
University of Virginia
* Washington and Lee University
* College of William and Mary

The Flexibility of Football Players

PETER O. SIGERSETH

University of Oregon
Eugene, Oregon

AND

CHESTER C. HALISKI

Marshfield High School
Coos Bay, Oregon

THERE has been a common belief that a high degree of flexibility is necessary for success in all athletic endeavors and that participation in any sport will improve this quality. Observation of outstanding football players while they were participating in basketball and other sports led the authors to question whether they possessed a high degree of flexibility in specific joints or bodily parts (2). The available literature was of little help because no research, except in swimming (1), and to lesser extent in gymnastics (6), had been made on the influence or relationship of flexibility to ability in specific sports.

The specific purposes of this study were [a] to compare the flexibility of 21 joints or areas of football players with that of normal college students (2), [b] to compare the flexibility of linemen and backfield men in the same joints and areas, and [c] to determine whether there is a difference in the flexibility of comparable right and left joints of the body.

Procedure

The data used in this study were obtained from 100 football players at the University of Oregon, none of whom had less than two years of high school and one year of college playing experience in the sport. This criterion was selected to make certain that the subjects who were tested had been exposed to football training long enough to allow for possible structural changes in the joints, if such occur as a result of intensive training in certain sports or activities.

Similar data had been collected earlier by Leighton (3) from 56 normal college students who were members of an elective service course class at the University of Oregon.

A goniometer called the Leighton Flexometer (3) was used in taking the flexibility measurements on both groups of subjects. The following measurements of flexibility were taken twice in succession on each subject: ankle flexion and extension, knee flexion, hip flexion, leg abduction, hip flexion and extension, trunk-hip flexion and extension, side trunk-hip flexion

wrist flexion and extension, arm flexion on back, elbow flexion, head rotation, head flexion and extension, and shoulder flexion and extension.

Analysis of the Data

The reliability of the measurements was first determined. This was done by correlating the first and second measurements of each variable. The reliability coefficients, shown in Table 1, ranged from .945 to .980 while

TABLE 1

Reliability of the tests

TEST VARIABLES	NUMBER OF CASES	RELIABILITY
L. Ankle (FE)	100	.980
R. Ankle (FE)	100	.964
L. Knee (F)	100	.964
R. Knee (F)	100	.978
L. Hip (F)	100	.977
R. Hip (F)	100	.975
L. Leg (Abd)	100	.953
R. Leg (Abd)	100	.945
L. Wrist (FE)	100	.977
R. Wrist (FE)	100	.980
L. Elbow (F)	100	.970
R. Elbow (F)	100	.967
L. Shoulder (FE)	100	.950
R. Shoulder (FE)	100	.949
Hip (FE)	100	.980
Trunk-Hip (FE)	100	.971
Side Trunk-hip (F)	100	.973
Head (Rot)	100	.961
Head (FE)	100	.977
L. Arm on back (F)	100	.967
R. Arm on back (F)	100	.970

Key to abbreviations: L = left; R = right; F = flexion; E = extension; Rot = rotation; Abd = abduction.

those reported by Leighton (3) ranged from .889 to .995. Since these reliabilities were high enough for purposes of comparison (5), the next step in the analysis was the comparison of the measurements of flexibility from the football players with those from the service course men.

The service course members were significantly (4) more flexible than the football players in 13 of the 21 measurements that were compared.[1] (Table 2.) The football players in turn were significantly more flexible than the service course members in only one of the comparable measures.

[1] The significance of the differences was based upon the null hypothesis that there is no significant difference between football players and service course members if t is less than 2.58.

TABLE 2

Means and standard deviations of football players and service course men, the difference between their means and their significance

TEST VARIABLE	100 FOOTBALL PLAYERS		56 SERVICE COURSE MEN		SERVICE COURSE MINUS FOOTBALL MEN	t
	Mean	σ	Mean	σ		
L Ankle FE	52.0°	9.3	62.6°	7.5	10.6°	7.79
R Ankle FE	54.8°	9.9	62.9°	8.3	8.1°	6.23
L Knee F	108.5°	13.0	123.7°	10.3	15.2°	8.00
R Knee F	115.1°	11.4	124.2°	9.8	9.1°	5.23
L Hip F	97.5°	13.8	106.6°	15.7	9.1°	3.63
R Hip F	93.2°	13.2	102.2°	12.4	8.0°	3.75
L Leg Abd	56.7°	8.0	54.6°	7.7	−2.1°	1.60
R Leg Abd	56.2°	7.7	55.6°	9.3	−0.6°	.41
L Wrist FE	153.4°	16.9	164.7°	17.8	11.3°	3.84
R Wrist FE	154.8°	17.6	162.9°	18.8	8.1°	2.63
L Elbow F	141.1°	9.5	148.7°	10.1	7.6°	4.58
R Elbow F	148.1°	9.0	150.1°	5.7	2.0°	1.70
L Shoulder FE	243.9°	14.1	244.4°	17.4	0.5°	.18
R Shoulder FE	245.7°	14.0	247.6°	15.5	1.9°	.75
Hip FE	91.3°	20.1	110.0°	24.2	18.7°	4.88
Trunk-hip FE	178.1°	19.2	173.0°	20.2	−5.1°	1.52
Side Trunk-hip F	110.7°	13.0	103.8°	13.8	−6.9°	3.04
Head Rot	171.4°	11.8	174.8°	18.9	3.4°	1.09
Head FE	131.9°	15.9	140.2°	16.9	8.3°	2.63
L Arm F on back	69.8°	15.7	82.1°	14.7	12.3°	4.86
R Arm F on back	66.5°	16.9	77.9°	14.8	11.4°	4.38

Key to abbreviations: L = left; R = right; F = flexion; E = extension; Abd = abduction; Rot = rotation.

TABLE 3

The means, standard deviations, differences between the means, and the critical ratio of the differences in the flexibility of football players' left and right joints

JOINT	LEFT		RIGHT		RIGHT MINUS LEFT	
	Mean	σ	Mean	σ		
Ankle	52.0	9.3	54.8	9.9	2.8	2.06
Knee	108.5	13.0	115.1	11.4	6.6	3.83
Hip	97.5	13.8	93.2	15.2	−4.3	2.10
Leg abduction	56.7	8.0	56.2	7.7	−0.5	.55
Wrist	153.4	16.9	154.8	17.6	1.4	.57
Elbow	141.1	9.5	148.1	9.0	7.0	5.34
Shoulder	243.9	14.1	245.7	14.0	1.8	.90
Arm flexed on back	69.8	15.7	66.5	16.9	−3.3	1.43

One hundred football players are represented in this table.

TABLE 4

The means, standard deviations, differences between the means, and the critical ratio of differences in the flexibility of service course men's left and right joints

JOINT	LEFT		RIGHT		RIGHT MINUS LEFT	t
	Mean	σ	Mean	σ		
Ankle	62.6	7.5	62.9	8.3	0.3	.11
Knee	123.7	10.3	124.2	9.8	0.5	.26
Hip	106.6	15.7	101.2	12.4	−5.4	2.00
Leg abduction	54.6	7.7	55.6	9.3	1.0	.62
Wrist	164.7	17.8	162.9	18.8	−1.8	.52
Elbow	148.7	10.1	150.1	5.7	1.4	.90
Shoulder	244.4	17.4	247.6	15.5	3.2	1.01
Arm flexed on back	82.1	14.7	77.9	14.8	−4.2	1.49

Fifty-six service course men are represented in this table.

TABLE 5

Means and the differences between the means in flexibility of linemen and backfield men

TEST VARIABLES	LINEMEN[a]		BACKFIELD[b]		DIFFERENCE	t
	Mean	σ	Mean	σ		
L. Ankle (FE)	51.57	21.95	52.44	24.37	.87	.18
R. Ankle (FE)	54.44	22.43	55.36	13.34	.92	.27
L. Knee (F)	109.57	14.46	108.13	21.95	1.44	.28
R. Knee (F)	114.46	23.87	115.46	22.69	1.00	.21
L. Hip (F)	98.33	25.77	96.39	28.76	1.94	.34
R. Hip (F)	92.57	26.02	94.44	25.12	1.87	.38
L. Leg (Abd)	56.46	20.24	57.59	20.64	1.13	.27
R. Leg (Abd)	55.59	20.70	56.88	17.49	1.29	.33
L. Wrist (FE)	154.16	22.58	152.23	33.68	1.93	.31
R. Wrist (FE)	155.08	26.74	152.92	28.81	2.16	.37
L. Elbow (F)	146.41	18.19	145.26	19.21	1.15	.29
R. Elbow (F)	147.67	18.47	146.49	16.34	1.18	.33
L. Shoulder (FE)	244.56	20.25	243.13	15.97	1.43	.38
R. Shoulder (FE)	244.51	20.35	247.82	14.07	3.31	.95
Hip (FE)	92.72	19.20	89.23	21.10	3.49	.83
Trunk-hip (FE)	178.15	20.07	179.00	21.75	0.85	.20
Side Trunk-hip (F)	109.21	18.08	112.90	15.52	3.69	1.07
Head (Rot)	171.00	23.04	172.00	28.57	1.00	.24
Head (FE)	130.26	22.93	132.46	17.06	2.20	.54
L. Arm on back (F)	70.39	21.82	67.82	22.98	2.57	.55
R. Arm on back (F)	67.49	19.16	64.62	22.93	2.87	.57

[a] Sixty-one Linemen.
[b] Thirty-nine backfield men.

When right and left side measurements of similar joints on football players were compared, only the differences between right and left knee flexion and between right and left elbow flexion were large enough to be significant (Table 3).[2] In no instance was the difference in flexibility between the right and left joints on service course members significant (Table 4).[3]

Table 5 reveals that there were no significant differences between linemen and backfield men in any of the measures of flexibility.

Summary

1. The service course members were significantly more flexible than the football players in 13 joints or areas.

2. The football players were significantly more flexible than service course members in only the area of side trunk-hip flexion.

3. The football players' right knees and right elbows were significantly more flexible than their corresponding left knees and left elbows. There was no other significant difference in the right and left measurements on football players.

4. There was no significant difference between any of the right and left side measurements of flexibility on the service course members.

5. There were no significant differences between linemen and backfield men in any of the measures of flexibility.

The subjects used in this study were selected on an athletic squad and service course class basis, and not in a random manner from among their own groups. They, therefore, may or may not be representative of all football players and college service course members in the total population. The evidence indicates clearly that, in the groups studied, college service course members are more flexible in a greater number of the body's joints and areas than are college football players.

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[2] The difference between right and left ankle flexibility and between right and left hip flexibility in football players was significant at the 5% level of confidence.

[3] The difference between the right and left hip flexibility in service course men was significant at the 5% level of confidence.

Improvement of Objective Strength Tests of Muscle Groups by Cable-Tension Methods[1]

H. Harrison Clarke

Physical Education Research Laboratory
Springfield College, Massachusetts

In THE May 1948 issue of the *Research Quarterly*, the initial research into cable-tension strength testing was reported.[2] In the course of this work, apparatus and objective techniques were devised for measuring the strength of muscles activating movements of the joints of the body. Twenty-eight tests were proposed, based on certain movements of the wrist, elbow, shoulder, hip, knee, and ankle. Coefficients of objectivity between 0.92 and 0.97 were obtained for the various tests by the test-retest method with different testers and with non-disabled college men as subjects. At present, strength tests for an additional sixteen joint movements are in process of construction.

In this type of objective strength testing, a specially adapted and calibrated aircraft tensiometer was utilized to record the amount of tension the subject can apply to a cable appropriately placed for specified movements. A homemade pulling apparatus was devised. These instruments are described in the previous report by the writer.[3] Subsequently, however, the tensiometer was improved for this purpose by the addition of a maximum pointer to facilitate reading the subject's score.[4]

Procedures

During the early experimentation with the cable-tension strength tests, it was noted that changes could be made in the techniques originally proposed in order to improve the tests as measures of the strength applied by muscles in activating various joint movements. As a result, the following three studies were made: the effect of alternate body positions, the selection

[1] Acknowledgements are sincerely made to Theodore L. Bailey, supervisor of the Physical Education Research Laboratory, and to the following graduate students who participated in the project: James L. DePasquale, Dean U. Harrell, Paul B. Kirkland, Donald K. Mathews, Henry J. Pilote, Jr., Edwin H. Richardson, Arthur R. Troisi, and Nicholas F. Troisi, Jr. All studies to date have been conducted under contract with the Office of Naval Research.

[2] H. Harrison Clarke, "Objective Strength Tests of Affected Muscle Groups Involved in Orthopedic Disabilities," *Research Quarterly*, May, 1948, Vol. 19, No. 4, p. 118–47.

[3] *Ibid.*

[4] Pacific Scientific Co., Inc., 1430 Grande Vista Avenue, Los Angeles, California.

of proper joint angles, and the location of strap positions. In addition, the effect of gravity in a number of the tests was studied.

In the test positions, the cable was always arranged at a right angle to the limb acting as a fulcrum; and the tensiometer was placed on the single-strand part of the pulling apparatus. In the studies, 0 degrees is a position away from the median line of the body; 180 degrees parallels and is in line with the median line. Thus, for example, 0 degrees in abduction of the shoulder is with the arm over the head; and at 180 degrees it is close to the body. In one test, shoulder flexion, the joint positions extended beyond 180 degrees to 240 degrees, as the arm was moved posteriorly.

The subjects tested for various phases of this research were 64 non-disabled male students at Springfield College.

ALTERNATE POSITIONS[5]

After extensive review by consultants on physical medicine at the Mayo Clinic,[6] alternate positions for 12 of the tests were suggested in order to avoid awkwardness, to eliminate items of special testing equipment, and to provide improved kinesiological positions for the muscles to function. As the proposals for change required experimentation, the subjects were tested in both the original and the revised positions in order to compare the amount of muscle strength applied.

In each case, the means of the tensions in both positions were computed. The differences between the means were tested for significance in accordance with the null hypothesis based upon "student's" distribution. On this basis, t-values of 1.67 and 2.37 denoted significance for small samples (64 cases) at the 0.05 and 0.01 levels of confidence respectively. These values for t were chosen because, in this study, significance was measured from zero, or no difference, in a positive direction only. In explanation, when the hypothesis tested postulates a difference in one direction only, the probability yielded by t as given in ordinary tables is halved.[7]

In nine of the test comparisons, improved positions, resulting in greater scores, were sought. The original forms of supination and pronation of the forearm were considered satisfactory, but, as a supinator-pronator machine was needed in their administration, the elimination of this equipment was desired. Consequently, an effort was made to find simpler forms of the tests that would obtain the same results as the originals. In adduction of the shoulder, elimination of the effect of the biceps muscle was attempted, which, if successful, would result in reduced scores on the test.

[5] Dean U. Harrell, *Further Refinement of Objective Orthopedic Strength Tests* Master's thesis. Springfield College, 1949. (Unpublished)

[6] Drs. Earl C. Elkins, Gordon M. Martin, and Khalil G. Wakim.

[7] Henry E. Garrett, *Statistics in Psychology and Education*. Third edition. New York: Longmans, Green and Company, 1947. p. 203.

SELECTION OF JOINT ANGLES[8]

In the initial work on the cable-tension strength tests, the joint angles for each of the tests were empirically selected after a brief trial of two or more positions. In order to determine these locations precisely, the muscle strength exerted throughout the full range of joint motion for 14 of the tests was determined. The test positions were as originally described,[9] except as modified in the study reported above.

Where joint movement through 180 degrees was possible for the joint, and was permitted in the test position, nine angles, approximately 20 degrees apart, were employed. Where either the joint or the test position did not permit a range of motion of 180 degrees, correspondingly fewer angles were utilized to portray the application of strength throughout the joint's range of motion. The fatigue element from repeated maximal exertions of the same muscles, while present, was reduced by spaced testing and was equalized by systematically changing (randomizing) the sequence of tests for the various subjects.

Graphs were prepared showing the muscle power exerted throughout the range of motion of the joints tested. The high point on the graph, i.e., the position at which greatest strength was recorded, was selected as the joint angle for each test.

STRAP POSITIONS

As was true with joint angles, the strap positions[10] for the various tensiometer strength tests were initially selected empirically after a brief trial of two or three. In the original tests, the strap was placed midway between the two joints in all tests except flexion and extension of the hip, where it was placed around the thigh one-third the distance from the knee joint, and inward and outward rotation of the hip joint, where it was placed around the lower leg just above the malleoli. In order to determine these locations more exactly, the muscle strength exerted at alternate strap positions for 12 of the tests was determined.

In each instance, the positions were: (a) at the original positions as described above; and (b) at the distal end of the appendage acting as a fulcrum for the joint movement. The mid-positions were found by estimating between the centers of motion of the adjacent joints involved. The distal locations were as follows:

Humerus: Just above olecranon process of elbow.
Radius: Just above syloid process of radius.
Femur: Just above popliteal surface.
Tibia: Just above maleolus.

[8] James L. DePasquale and Donald K. Mathews, *Joint Angles and Strap Positions of Othopedic Strength Tests as Applied to Non-Disabled College Men.* Master's thesis, Springfield College, 1949. (Unpublished)

[9] H. Harrison Clarke, *op. cit.*

[10] DePasquale and Mathews, *op. cit.*

A comparison of mean performances of the subjects with straps in the different positions for each of the tests was made. Significance of differences between the means was tested by the null hypothesis, with *t*'s of 1.67 and 2.37, denoting significance at the 0.05 and 0.01 levels of confidence respectively, as in the study of alternate body positions.

EFFECT OF GRAVITY

In reviewing these strength tests with the doctors of physical medicine at the Mayo Clinic, it was noted that the pull of gravity on the limb was not controlled: in some instances, the entire weight of the limb was recorded in the test; at other times, the effect of gravity was absent entirely; and, in still others, varying amounts of gravity were in force. As a result, the gravity factor of seven of the tests, where the weight of the limb acting as fulcrum entered into the test results, was studied.

In determining the gravity factor in each instance, the limb was placed in position for the test, suspended in the pulling apparatus with the strap located at the pulling point and at right angles to the limb. With the limb in a relaxed condition, the tension applied to the cable was measured with the tensiometer and was converted to pounds on the calibration chart for recording.

As will be noted, the weight of the limb at the testing position only is recorded by this process. No account is taken of leverage or the angle of pull by muscles in relation to their origins and insertions. Actually, therefore, muscles may require much more strength than the actual poundage recorded in order to move the limb.

Results of the Studies

In conducting this study, four of the original cable-tension strength tests were not subjected to further investigation, so their techniques remain the same as in the initial report. These tests are: wrist dorsal flexion, wrist palmar flexion, hip inward rotation, and hip outward rotation. Each of the remaining tests will be considered below in turn. The results of the joint-angle study and graphs will not be given in detail in this report as they are reported elsewhere.[11] However, the selected angle from the study will be specified in each instance.

FOREARM SUPINATION

Alternate position: As the original form of this test required a supinator-pronator machine, an effort was made to devise a testing technique which

[11] H. Harrison Clarke, "Testing Muscle Strength," *Research Reviews*, January, 1950. p 1.

H. Harrison Clarke, Earl C. Elkins, Gordon M. Martin, and Khalil G. Wakim, "Relationship Between Body Position and the Application of Muscle Power to Movements of the Joints," *Archives of Physical Medicine*, Vol. 31. No. 2. February, 1950. p. 81–89.

H. Harrison Clarke, Theodore L. Bailey, "Strength as Applied Throughout the Range of Fourteen Joint Movements," *Journal of the Association for Physical and Mental Rehabilitation*, Vol. 4, No. 2. April, 1950.

would eliminate this item of equipment. Two possibilities were studied as follows: (a) Instead of grasping the handle of the supinator-pronator machine, the subject grasped the pulling-strap webbing and supinated. (b) The subject grasped a short handle with a hook on the end to which the cable was fastened and performed the test.

The resultant means in this study were as follows: original form, grasping supinator-pronator machine, 29.17 pounds; grasping strap, 33.02 pounds; and grasping hook-handle, 30.56 pounds. The increase with the strap was 3.85 pounds, t of 2.26, which is statistically significant. As a test comparable to the original form was sought, the revision was rejected.

The difference between the means when the hook-handle assembly was used is not statistically significant ($t = 0.95$). By this comparison, the revised form is acceptable. Subsequently, however, an objectivity coefficient of 0.68 was obtained, by the test-retest method utilizing different testers. As a consequence of this demonstrated inaccuracy in the testing process, this form was also rejected.

FOREARM PRONATION

Alternate positions: The same studies as for forearm supination were conducted for forearm pronation with essentially the same results. The difference between the means of the original test with supinator-pronator machine and grasping the strap was statistically significant ($t = 6.88$); the difference between the original form and grasping the hook-handle was not statistically significant ($t = 0.68$). However, the objectivity coefficient for the latter form was 0.71, which resulted in its rejection. As a result, the test form with supinator-pronator machine was continued in effect.

ELBOW FLEXION

Angle study: The angle selected was 115 degrees.

Strap study: An average of 99 pounds was pulled with the strap at the mid-position; and an average of 74 pounds, at the distal-position. The difference of 25 pounds, t of 7.31, is statistically significant, so the original position of the strap was continued in the testing technique.

Gravity study: The gravity factor in this test position was found to be slight. In interpreting this result, some doubt is expressed as to the ability of the cable-tension testing technique to record and measure accurately weights in the lower ranges, under five pounds particularly.

Test changes: The angle at the elbow joint was changed to 115 degrees (from 90 degrees).

ELBOW EXTENSION

Angle study: The angle selected was 40 degrees.

Strap study: The average pull with the strap at mid-position was 65 pounds; at distal-position, 51 pounds. The difference of 14 pounds is statistically significant, t of 4.03, so the original position of the strap was continued.

Gravity study: The results were the same as for the elbow flexion test.

Test changes: The angle at the elbow joint was changed to 40 degrees (from 160 degrees).

SHOULDER ADDUCTION

The test for downward rotation of the scapula was combined with shoulder adduction, as the movements merge as the arm is lowered sidewards from an overhead position to one close to the side of the body: angles for downward rotation of the scapula are from 0 to 90 degrees; and for shoulder adduction, 90 to 180 degrees.

Alternate position: In the original form, the subject was in supine lying position, with hips and knees flexed, feet resting on table and free arm on chest; arm being tested adducted at shoulder to 160 degrees, elbow in thrust position, and forearm in midprone-supine position. The same position was used in the alternate form, except, in order to eliminate the effect of the biceps muscle, the humerus was rotated inward by turning forearm across chest; hand was held low toward opposite shoulder.

The mean for the original form of the test was 63.00 pounds; for the alternate form, 52.25 pounds. The difference of 10.75 pounds is statistically significant, t of 3.90. As this difference is attributed to the elimination of the biceps muscle from the test, the alternate form was accepted.

Angle study: The angle selected was 110 degrees.

Strap study: The average pull with the strap at mid-position was 119 pounds; at distal-position, 95 pounds. The difference of 24 pounds is statistically significant, t of 4.53, so the original position of the strap was continued.

Test changes: (a) The alternate position for the test, described above was adopted; and (b) the angle at the shoulder joint was changed to 110 degrees (from 160 degrees).

SHOULDER ABDUCTION

The test for upward rotation of the scapula was combined with shoulder abduction, as the movements merge in the same manner as described for shoulder adduction.

Angle study: The angle selected was 180 degrees.

Strap study: The average pull with the strap at mid-position was 109 pounds; at distal-position, 105 pounds. The difference of four pounds is not statistically significant ($t = 0.69$). Inasmuch as results obtained by the two positions are comparable, however, the distal-position was accepted, as it facilitated placing the strap and cable under the subject's back, which is necessary in the administration of this test.

Test changes: (a) The angle at the shoulder joint was changed to 180 degrees (from 110 degrees); and (b) position of the strap was shifted to the distal end of the limb acting as fulcrum for the movement.

SHOULDER FLEXION

The test for extension of the shoulder-girdle was combined with shoulder flexion, as the movements merge as the arm is lowered forward from an overhead position to one close to the side of the body: angles for extension of the shoulder girdle are 0 to 90 degrees; and for shoulder-flexion, 90 to 180 degrees.

Alternate position: In the original form, the subject was in supine lying position, with hips and knees flexed, feet resting on table and free arm on chest; arm being tested flexed at shoulder to 135 degrees, elbow in thrust position, and forearm in midprone-supine position. The same position was used in the alternate form, except, in order to eliminate the possible effect of the biceps muscle, the humerus was rotated inward by turning forearm across chest; hand was held low toward opposite shoulder.

The mean for the original form of the test was 77.13 pounds; for the revised form, 73.5 pounds. As the difference of 3.63 pounds is not statisitcally significant ($t = 1.13$), the alternate position was rejected.

Angle study: The angle selected was 240 degrees.

Strap study: An average of 94 pounds was pulled with the strap at the mid-position; and an average of 72 pounds, at the distal-position. The difference of 22 pounds, t of 5.30, is statistically significant, so the original position of the strap was continued in the testing technique.

Gravity study: The gravity factor in this test position was found to average 8.88 pounds. This amount of weight is lifted in the test, in addition to the amount recorded on the tensiometer.

Test changes: The angle at the shoulder joint was changed to 240 degrees (from 135 degrees). To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the test score.

SHOULDER EXTENSION

The test for flexion of the shoulder girdle was combined with shoulder extension, as the movements merge in the same manner as described for shoulder flexion.

Angle study: The angle selected was 90 degrees.

Strap studies: An average of 92 pounds was pulled with the strap in mid-position; and an average of 77 pounds, in distal-position. The difference of 15 pounds, t of 3.92, is statistically significant, so the original position of the strap was continued in the testing technique.

Test change: The angle at the shoulder joint was changed to 90 degrees (from 135 degrees).

SHOULDER INWARD ROTATION

Strap study: The average pull for the strap at mid-position was 68 pounds; at distal-position, 50 pounds. The difference of 18 pounds is statistically significant, t of 8.19, so no change was made in this test.

SHOULDER OUTWARD ROTATION

Strap study: An average of 48 pounds was pulled with the strap in mid-position; and 36 pounds, in distal-position. The difference of 12 pounds is statistically significant, t of 5.32, so no change in this test was made.

HIP FLEXION

Alternate position: In the original form, the subject was in supine lying position, leg not tested resting on table, arms folded on chest; thigh being tested flexed at hip to 120 degrees, knee flexed with angle not specified. In the alternate form, the subject was sitting at the end of the testing table, leaning backward with arms extended to rear and hands grasping sides of table, legs hanging free; the hip on side of thigh being tested flexed to 90 degrees, knee in 90 degrees flexion.

The mean for the original form of the test was 64.81 pounds; for the alternate form, 115.00 pounds. The average for the revised form was 50.19 pounds greater, an improvement of 77%; the t was 15.78. As a result of this significant increase, the revised form was accepted.

Angle study: The angle selected was 90 degrees.

Strap study: The average pull for the strap at the one-third position was 118 pounds; at distal-position, 89 pounds. The difference of 29 pounds is statistically significant, t of 5.03, so no change in the test was made.

Gravity study: The gravity factor in this test position was found to average 25.27 pounds. This amount of weight is lifted in the test, in addition to the amount recorded on the tensiometer.

Subsequently, an objectivity coefficient of 0.91 was obtained for the revised form of this test by the test-retest method utilizing different testers.

Test changes: The alternate form of the test was accepted, with the hip in 90 degrees flexion. To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the test score.

HIP EXTENSION

Alternate position: In the original form, the subject was in sitting position at the end of the testing table, legs hanging free, arms folded on chest; the thigh being tested was flexed at hip to 70 degrees, and knee flexed with angle unspecified; an overhead hook was used to fasten the cable. In the alternate form, the subject was in supine lying position, free leg flexed at knee with foot resting on table, arms folded on chest; thigh being tested was flexed at hip to 90 degrees, and knee flexed with angle unspecified.

The mean for the original test was 73.25 pounds; for the revised form, 130.75 pounds. The average for the revised form was 57.50 pounds greater; the t was 8.46. As a definite statistical significance was found, the alternate form was accepted.

Subsequently, in further examination of the test, it was noted that the

hamstring muscles function in this test if the knee is allowed to straighten. To check on the effect of this factor, the revised form of the test was administered to the subjects with the knee angle uncontrolled and with the knee bent close to the thigh. The strength applied in the uncontrolled movement was 11.16 pounds greater than the knee-controlled movement, which is just significant at the 0.05 level of confidence.

Angle study: The angle selected was 50 degrees.

Strap studies: An average of 120 pounds was pulled with the strap at the one-third position; and an average of 186 pounds, at the distal-position. The difference of 66 pounds, t of 6.39, is statistically significant, so the change in testing technique was made. (This difference is probably greater than that reported as in another study, these data were found to be truncated at the upper end of the testing scale due to a 300-pound limitation in the tensiometer used.)

Gravity study: The gravity factor in this test position was found to average 33.03 pounds. This amount of weight is recorded in the test score. Subsequently, an objectivity coefficient of 0.93 was obtained for this test, as finally revised.

Test changes: The alternate form of the test was accepted, with the hip in 50 degrees flexion. If the effect of the hamstring muscles is to be eliminated from the test score, the knee of the leg being tested should be flexed against the thigh. To record the actual weight lifted by the muscles in this test, the weight of the limb should be subtracted from the test score.

HIP ADDUCTION

Alternate position: In the original test, the subject was in supine lying position, legs hanging free over end of table, arms folded on chest; the thigh being tested was adducted at hip to 160 degrees. The alternate position was the same, except the entire body was resting on the table.

The mean for the original form of the test was 58.81 pounds; for the alternate position, 69.88 pounds. The difference of 13.07 pounds in favor of the alternate form is statistically significant, t of 4.16, so the revision was accepted.

Angle study: The angle selected was 135 degrees.

Test changes: The alternate form of the test was accepted, with the hip in 135 degrees adduction.

HIP ABDUCTION

Alternate position: The same shift in position as for hip adduction was studied. The mean for the original form of the test was 59.08; for the alternate form, 66.37 pounds. The average for the alternate form was 7.29 pounds greater; the t was 2.79. As this difference is statistically significant just beyond the 0.01 level of confidence, the revision was accepted.

Angle study: The angle selected was 180 degrees.

Test changes: The alternate form of the test was accepted, with the hip in 180 degrees adduction.

KNEE FLEXION

Alternate position: In the original form of the test, the subject was in prone lying position, lower legs extended beyond end of table, arms folded above the head; the leg being tested was flexed at knee to 135 degrees, hips blocked by tester to prevent raising. The alternate form was the same, except the block to prevent hip raising was eliminated.

The mean for the original form of the test was 95.9 pounds; the revised form, 98.88 pounds. The difference between the means of 2.98 pounds, t of 0.75, is not statistically significant. Although the difference was not significant, the revision was accepted as it simplified administration of the test.

Angle study: The angle selected was 165 degrees.

Strap study: An average of 102 pounds was pulled with the strap at the mid-position; and an average of 60 pounds, at the distal-position. The difference of 42 pounds, t of 18.95, is statistically significant, so no change in testing technique was made.

Gravity study: The gravity factor in this test was found to average 13.75 pounds. This amount of weight is lifted in addition to the test score.

Test changes: The alternate form of the test was accepted, with the knee in 165 degrees flexion. To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the test score.

KNEE EXTENSION

Alternate position: In the original form of the test, the subject was in a sitting position at end of testing table, free leg hanging free, arms folded on chest; knee of leg being tested was in 135 degrees flexion. The alternate form was the same, except the subject leaned backward grasping sides of the table.

The mean for the original form of the test was 112.94 pounds, for the alternate form, 147.94 pounds. The average for the alternate form was 35.00 pounds greater; the t was 4.86, indicating a statistically significant difference, so the revision was accepted.

Angle study: The angle selected was 115 degrees.

Gravity study: The gravity factor in this test was found to average 10.40 pounds. This amount of weight is lifted in addition to the test score.

Test changes: The alternate form of the test was accepted, with the knee in 115 degrees flexion. To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the test score.

ANKLE DORSAL FLEXION

Alternate position: In the original form of the test, the subject was in prone lying position, free leg extended at knee to 180 degrees, arms resting on table at side of head; knee of leg being tested flexed to 90 degrees, ankle

in 90 degrees dorsal flexion, and in mid-position of inversion and eversion; an overhead hook was used to attach the cable. In the alternate form, the subject was in supine lying position, legs extended at hip and knee joints to 180 degrees, arms folded on chest; ankle being tested was in 90 degrees dorsal flexion, and in midposition of inversion and eversion.

The mean for the original form of the test was 53.72 pounds; for the alternate form, 71.69 pounds. The average for the revised form was 17.97 pounds greater, t of 6.44, a statistically significant difference, so accepted as a test revision.

Angle study: The angle selected was 125 degrees.

Inasmuch as the revised form of this test resulted in considerable change in basic body position, an objectivity study was conducted by the test-retest method with several testers. A coefficient of 0.93 was obtained.

Test changes: The alternate form was accepted, with the ankle angle at 125 degrees.

ANKLE PLANTAR FLEXION

Alternate position: In the original form of the test, the subject was in a sitting position at the end of the testing table, legs hanging free, arms folded on chest; knee of leg being tested in 90 degrees flexion, ankle in 90 degrees plantar flexion with mid-position of inversion and eversion; the cable was attached overhead. In the alternate form, the subject was in the same position as for dorsal flexion of the ankle.

The mean for the original form of the test was 61.84 pounds; for the revised form, 129.50 pounds. The average for the alternate form was 67.77 pounds greater, an improvement of 109%. The revision was accepted.

Angle study: The angle selected was 90 degrees.

Because changes in the basic body position for the revised form of this test were necessary, an objectivity study was conducted. The resultant coefficient was 0.93.

Test changes: The alternate form was accepted, with the ankle angle in 90 degrees.

TEST DESCRIPTIONS

Following are descriptions of the cable-tension strength tests for joint movements of the wrist, elbow, shoulder, hip, knee, and ankle, as finally retained and revised. Drawings illustrating the various tests appear at the end of the article.

TESTS AT WRIST JOINT

1. *Wrist Dorsal Flexion* (Illustrated)
   Starting Position
   a. Subject sitting on chair; feet resting on floor.
   b. Arm adducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees.
   c. Elbow in 90 degrees flexion; forearm in mid-prone and supine position.
   d. Wrist in mid-position of range of motion for dorsal and palmar flexion; forearm resting upon table; free arm on table bracing arm of wrist being tested.

Attachments

a. Center of strap around dorsum of hand 1″ above the metacarpo-phalangeal joint.

b. Cable attached to the wall facing palm of wrist being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions

a. Prevent arm abduction at shoulder: tester block elbow close to side of subject.

b. Prevent elevation of shoulder: tester block on top of shoulder.

2. *Wrist Palmar Flexion*

Starting Position

a. Subject sitting on chair; feet resting on floor.

b. Arm adducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees.

c. Elbow in 90 degrees flexion; forearm in mid-prone and supine position.

d. Wrist in mid-position of range of motion for dorsal and palmar flexion; forearm resting upon table; free arm on table bracing arm of wrist being tested.

Attachments

a. Center of straps around palm of hand 1 inch above the metacarpo-phalangeal joint.

b. Cable attached to wall facing dorsum of wrist being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions

a. Prevent arm abduction at shoulder: tester block elbow close to side of subject.

b. Prevent elevation of shoulder: tester block on top of shoulder.

(The illustration is similar to Wrist Dorsal Flexion, except cable is attached to opposite side.)

3. *Forearm Supination*

Starting Position

a. Patient sitting on chair; feet resting on floor.

b. Arm adducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees.

c. Elbow in 90 degrees flexion; forearm resting upon table at right angle with wall.

d. Forearm in 100 degrees pronation; hand grasping handle of pronator-supinator machine; free arm on thigh.

Attachments

a. Cable attached to wall at right of supinator-pronator machine.

b. Attachment to supinator-pronator machine at lower part of handle for right hand; attachment at upper part of handle for left hand.

c. In case cable is attached to wall at left side of pronator-supinator machine, these positions will be reversed.

Direction of Pull: Parallel with horizontal plane and wall.

Precautions

a. Prevent dorsal flexion at wrist.

b. Prevent arm abduction at shoulder: tester block elbow close to side of subject.

c. Prevent lateral flexion of spine: tester block across top of shoulder on side being tested.

(The illustration is similar to Forearm Pronation, except cable is hooked at bottom of supinator-pronator machine and attached to opposite side.)

4. *Forearm Pronation* (Illustrated)

Starting Position

a. Same as for test of "forearm supination," except forearm in 80 degrees supination (instead of 100 degrees pronation).

Attachments

a. Cable attached to wall at right of supinator-pronator machine.
b. Attachment to supinator-pronator machine at upper part of handle for right hand; attachment at lower part of handle for left hand.
c. In case table is attached to wall at left side of pronator-supinator machine, these positions will be reversed.

Direction of Pull: Parallel with horizontal plane and wall.

Precautions

a. Prevent palmar flexion of wrist.
b. Prevent arm abduction at shoulder: tester block elbow close to side of subject.
c. Prevent lateral flexion of spine: tester block across top of shoulder on side being tested.

TESTS AT ELBOW JOINT

5. *Elbow flexion* (Illustrated)

Starting Position

a. Subject in supine lying position, hips and knees flexed; feet resting on table.
b. Arm adducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees; forearm in vertical plane.
c. Elbow in 115 degrees flexion.
d. Forearm in mid-prone-supine position.
e. Hand of free arm resting on chest.

Attachments

a. Center of strap around forearm midway between wrist and elbow joints.
b. Cable hooked to wall at subject's feet.

Direction of Pull: Parallel with median line.

Precautions

a. Adjust forearm so that the elbow is in 115 degrees flexion at height of pull.
b. Prevent raising elbow and abducting upper arm by bracing elbow at joint.

Note: This test may be given with forearm in the following three positions: (a) in as much supination as possible; (b) in as much pronation as possible; and (c) in midprone-supine position.

6. *Elbow Extension* (Illustrated)

Starting Position

a. Subject in supine lying position, hips and knees flexed; feet resting on table.
b. Arm adducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees; forearm in vertical plane.
c. Elbow in 40 degrees flexion.
d. Forearm in mid-prone-supine position.
e. Hand of free arm resting on chest.

Attachments

a. Center of strap around forearm midway between wrist and elbow joints.
b. Cable hooked to wall at subject's head.

Direction of Pull: Parallel with median line.

Precautions

a. Adjust forearm so that the elbow is in 40 degrees flexion at height of pull.
b. Prevent shoulder elevation by bracing with hand.
c. Prevent raising elbow and abducting upper arm by bracing elbow to side.
d. Require subject to keep head straight so as to reduce tendency to flex the spine laterally.

TESTS AT SHOULDER JOINT

7. *Shoulder Adduction* (Illustrated)

Starting Position

a. Subject in supine lying position, hips and knees flexed; feet resting on table.

b. Arm adducted at shoulder to 110 degrees; arm extended at shoulder to 180 degrees; humerus rotated inward by turning forearm across chest, hand held low, to eliminate effect of biceps muscle.
c. Hand of free arm resting on chest.

Attachments

a. Center of strap around humerus midway between shoulder and elbow joints.
b. Cable attached to wall at head of subject being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions

a. Prevent elevation of shoulder.
b. Tester should aid in administration by bracing shoulders with hands.

8. *Shoulder Abduction* (Illustrated)

Starting Position

a. Subject in supine lying position, hips and knees flexed; feet resting on table; free arm on chest.
b. Arm abducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees.
c. Elbow at 90 degrees flexion.
d. Forearm in mid-prone-supine position.
e. Folded towel placed under buttocks and one midway between scapulae to exaggerate lumbar curve anteriorly in order to permit passage of pulling strap and cable.

Attachments

a. Center of strap around distal end of humerus, just above olecranon process of elbow.
b. Cable passes under subject's back and attached to wall opposite side of limb being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions

a. Prevent shoulder elevation by bracing with hand.
b. Prevent raising elbow by bracing with hand.
c. Prevent lateral trunk flexion by bracing with hand.

9. *Shoulder Flexion* (Illustrated)

Starting Position

a. Subject in supine lying position, hips and knees flexed; feet resting on table free arm on chest.
b. Arm abducted at shoulder to 180 degrees; flexion of shoulder to 240 degrees.
c. Elbow flexed to 90 degrees.

Attachments

a. Center of strap around humerus midway between shoulder and elbow joints.
b. Cable attached to hook on side of plinth below subject's arm.

Direction of Pull: Parallel with vertical plane.

Precautions

a. Prevent shoulder elevation by bracing with hand.
b. Maintain right angle at elbow.

(To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the score.)

10. *Shoulder Extension* (Illustrated)

Starting Position

a. Subject in supine lying position, hips and knees flexed; feet resting on table; free arm on chest.
b. Arm adducted at shoulder to 180 degrees; flexion of shoulder to 90 degrees.
c. Elbow flexed with wrist in prone position.

Attachments

a. Center of strap around humerus midway between shoulder and elbow joints.
b. Cable attached to wall at subject's head.

Direction of Pull: Parallel with medial line.
Precautions
a. Prevent shoulder elevation by bracing with hand.
b. Prevent humerus abduction by guiding with hand.

11. *Shoulder Inward Rotation* (Illustrated)
Starting Position
a. Subject in supine lying position, hips and knees flexed; feet resting on table; free arm on chest.
b. Arm adducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees.
c. Elbow at 90 degrees flexion; elbow supported by pad to bring upper arm into position parallel to table.
d. Forearm in mid-prone supine position.
Attachments
a. Center of strap around forearm midway between elbow and wrist joints.
b. Cable attached to wall at side of limb being tested.
Direction of Pull: Parallel with horizontal plane.
Precautions
a. Adjust forearm so that it is vertical at height of pull.
b. Prevent "cupping" shoulder by bracing with hand.
c. Prevent raising elbow and abducting upper arm by bracing elbow to side and hooking thumb over arm at elbow joint.

12. *Shoulder Outward Rotation*
Starting Position
a. Subject in supine lying position, hips and knees flexed; feet resting on table; free arm on chest.
b. Arm adducted at shoulder to 180 degrees; arm extended at shoulder to 180 degrees.
c. Elbow at 90 degrees flexion; elbow supported by pad to bring upper arm into position parallel to table.
d. Forearm in mid-prone-supine position.
Attachments
a. Center of strap around forearm midway between elbow and wrist joints.
b. Cable attached to wall at opposite side of limb being tested.
Direction of Pull: Parallel with horizontal plane.
Precatuion
a. Adjust forearm so that it is vertical at height of pull.
b. Prevent "cupping" shoulder by bracing with hand.
c. Prevent raising elbow and abducting upper arm by bracing elbow to side and hooking thumb over arm at elbow joint
(The illustration is similar to Shoulder Inward Rotation, except cable crosses body and is attached to the opposite side.)

TESTS AT HIP JOINT

13. *Hip Flexion* (Illustrated)
Starting Position
a. Subject in sitting, backward-leaning position, legs hanging free; arms extended to rear, hand grasping sides of table.
b. Thigh in 90 degrees flexion at hip joint; thigh adducted at hip to 180 degrees.
c. Knee in 90 degrees flexion.
Attachments
a. Strap around thigh, lower third between hip and knee joints.
b. Cable attached to foremost hook at lower end of table.
Direction of Pull: Parallel with vertical plane.
Precautions
a. Prevent lifting of buttocks; elbows should remain locked.

(To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the test score.)

14. *Hip Extension* (Illustrated)
    Starting Position
    a. Subject in supine lying position; arms folded on chest.
    b. Thigh in 50 degrees flexion at hip joint; thigh adducted at hip joint to 180 degrees.
    c. Knee flexed, with angle unspecified.
    Attachments
    a. Strap around thigh, just posterior to popliteal surface.
    b. Cable attached to wall at subject's head on lower hook.
    Direction of Pull: Diagonal with horizontal plane.
    Precautions
    a. Prevent lifting buttocks.
    b. Brace against shoulders.
    (If the effect of the hamstring muscles is to be eliminated from the test score, the knee of the leg being tested should be flexed against the thigh. Also, to record the actual weight lifted by the muscles in this test, the weight of the limb should be subtracted from the test score.)
15. *Hip Adduction* (Illustrated)
    Starting Position
    a. Subject in supine lying position; arms folded on chest.
    b. Leg in 180 degrees extension at hip and knee joints; free leg resting on table.
    c. Thigh adducted at hip joint to 135 degrees.
    Attachments
    a. Strap around thigh, lower third between hip and knee joints.
    b. Cable attached to wall at side of limb being tested.
    Direction of Pull: Parallel with horizontal plane.
    Precautions
    a. Prevent flexion of thigh at hip joint.
    b. Brace against free leg and hip of side being tested.
16. *Hip Abduction* (Illustrated)
    Starting Position
    a. Subject in supine lying position; arms folded on chest.
    b. Leg in 180 degrees extension at hip and knee joints; free thigh flexed at hip to allow cable clearance.
    c. Thigh adducted at hip joint to 180 degrees.
    Attachments
    a. Strap around thigh, lower third between hip and knee joints.
    b. Cable attached to opposite wall from limb being tested.
    Direction of Pull: Parallel with horizontal plane.
    Precautions
    a. Prevent flexion of thigh at hip joint.
    b. Brace against hip being tested; prevent tilting of pelvis.
17. *Hip Inward Rotation* (Illustrated)
    Starting Position
    a. Subject in sitting position on table, legs hanging free, arms folded on chest.
    b. Thigh in 90 degrees flexion at hip joint; thigh adducted at hip joint to 180 degrees.
    c. Knee in 90 degrees flexion; padded support under knee.
    Attachments
    a. Center of strap around leg 4″ above ankle joint.
    b. Cable attached to wall on side away from limb being tested.
    Direction of Pull: Parallel with horizontal plane and at right angles to median line.

Precautions

a. Prevent adduction and flexion of thigh at hip joint; tester should aid by bracing thigh with hands.
b. Prevent eversion at ankle joint.

18. *Hip Outward Rotation*

Starting Position

a. Subject in sitting position on table, legs hanging free, arms folded on chest.
b. Thigh in 90 degrees flexion at hip joint; thigh adducted at hip joint to 180 degrees.
c. Knee in 90 degrees flexion; padded support under knee.

Attachments

a. Center of strap around leg 4″ above ankle joint.
b. Cable attached to wall on side of limb being tested.

Direction of Pull: Parallel with horizontal plane, and at right angles to median line.

Precautions

a. Prevent abduction and flexion of thigh at hip joint; tester should aid by bracing thigh with hands.
b. Prevent inversion at ankle joint.

(The illustration is similar to Hip Inward Rotation, except cable is attached to opposite side.)

TESTS AT KNEE JOINT

19. *Knee Flexion* (Illustrated)

Starting Position

a. Patient in prone lying position; patellae just at the edge of plinth.
b. Head resting on folded arms.
c. Knee flexed to 165 degrees

Attachments

a. Center of strap around leg midway between the knee and ankle joints.
b. Cable attached to hook at base of plinth.

Direction of Pull: Parallel with vertical plane.

Precautions

a. Prevent extension of spine by holding chest on table.
b. It is permissible to flex hips.

(To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the test score.)

20. *Knee Extension* (Illustrated)

Starting Position

a. Subject in sitting, backward-leaning position; legs hanging free; arms extended to rear, hands grasping sides of table.
b. Thigh adducted at hip joint to 180 degrees.
c. Knee in 115 degrees extension.

Attachments

a. Center of strap around leg midway between knee and ankle joints.
b. Cable attached to rearmost hook at lower end of table.

Direction of Pull: Parallel with median line.

Precautions

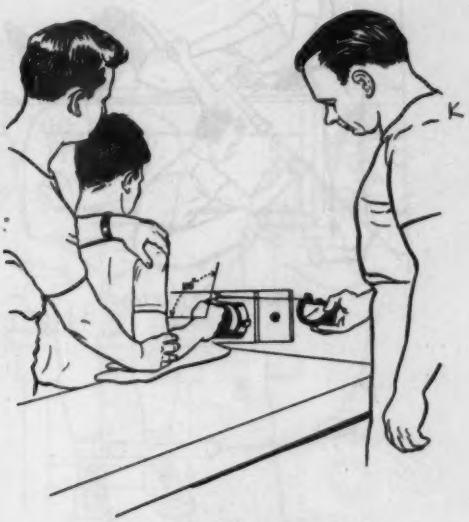
a. Prevent lifting buttocks.
b. Prevent flexion of arms.

(To record the actual weight lifted by the muscles in this test, the weight of the limb in test position should be added to the test score.)

TESTS AT ANKLE JOINT

21. *Ankle Dorsal Flexion* (Illustrated)
    Starting Position
    a. Subject in supine lying positions; arms folded on chest.
    b. Leg in 180 degrees extension; leg adducted to 180 degrees.
    c. Ankle in 125 degrees dorsal flexion, ankle in midposition of inversion and eversion.
    Attachments
    a. Center of strap around foot 1″ above metatarsal-phalangeal joint.
    b. Cable attached to wall at subject's feet.
    Direction of Pull: Parallel with horizontal plane.
    Precautions
    a. Prevent inversion or eversion at ankle joint.
    b. Prevent flexion at metatarsal-phalangeal joint.
    c. Prevent flexion of knee; tester should aid by holding leg against table.
22. *Ankle Plantar Flexion* (Illustrated)
    Starting Position
    a. Subject in supine lying position; arms folded on chest.
    b. Leg in 180 degrees extension; leg adducted to 180 degrees.
    c. Ankle in 90 degrees plantar flexion; ankle in mid-position of inversion and eversion.
    Attachments
    a. Center of strap around foot above metatarsal-phalangeal joint.
    b. Cable attached to wall at subject's head.
    Direction of Pull: Parallel with horizontal plane.
    Precautions
    a. Prevent inversion or eversion at ankle joint.
    b. Prevent extension of metatarsal-phalangeal joint.
    c. Prevent raising leg.
    d. Brace behind shoulders.

WRIST DORSAL FLEXION



FOREARM PRONATION

ELBOW FLEXION

ELBOW EXTENSION

SHOULDER ADDUCTION

SHOULDER ABDUCTION

SHOULDER FLEXION

SHOULDER EXTENSION

SHOULDER INWARD ROTATION

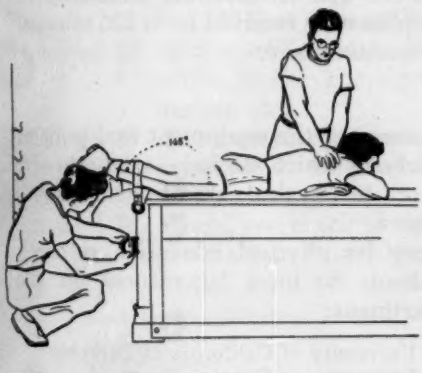
HIP FLEXION

HIP EXTENSION

HIP ADDUCTION

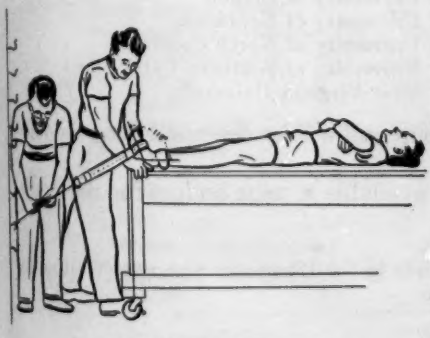
HIP ABDUCTION

HIP INWARD ROTATION



KNEE FLEXION

KNEE EXTENSION



ANKLE DORSAL FLEXION

ANKLE PLANTAR FLEXION

A Survey of Laboratory Facilities in College Physical Education Departments[1]

PAUL HUNSICKER

Physical Education Department
University of Michigan

THE WRITER is in the process of planning a laboratory for research work in physical education at the University of Michigan and was interested in knowing what other colleges are doing in this field. It was felt that a questionnaire survey would prove helpful to anyone planning on expanding his department in this direction.

Procedure

A questionnaire was sent to 148 colleges and universities in the United States to determine the status of laboratory facilities in the Physical Education Departments at these schools. The letters were addressed to the Director of Physical Education. Replies were received from 125 schools, or approximately 84% answered the questionnaire.

Results

The following data represent a summary of the equipment and policies concerning research work at the 16 schools which do have a laboratory:

Question 1. Do you offer graduate work in physical education? Master's degree 16. Doctor's degree 8.

Question 2. Do you have a laboratory for physical education research work? The following schools do have laboratories in the Physical Education Department:

George Williams College
Indiana University
Oregon State College
New York University
Pennsylvania State College
Springfield College
Smith College
University of Alabama
University of California at Berkeley
University of Illinois
University of Iowa
University of Oregon
University of Nebraska
University of North Carolina
University of Southern California
West Virginia University

Question 3. Did not apply to this group and will be discussed later in the paper.

Question 4. Do you have any money available in your budget for research work? Yes 13. No 3.

[1] The writer wishes to extend his gratitude to the 125 people who were willing to take the time to answer the questionnaire.

Question 5. Do the graduate students have access to laboratory facilities in other departments for research work in physical education? Which departments? Yes 14. No 2.

No	*Department*	*No.*	*Department*
2	All departments	3	Nutrition
1	Anatomy	1	Physics
1	Aviation medicine	4	Physiology
1	Biology	5	Psychology
2	Chemistry	1	Statistics
2	Education	1	Zoology

Question 6. How many rooms do you have in your laboratory? The answers ranged from 1 room to 8 rooms with a median at 2.5 rooms.

Question 7. What is the approximate floor space of the laboratory? The replies varied between 120 square feet and 5000 square feet with a median value of 650 square feet.

Question 8. How many staff members use the laboratory for research? Between 1 and 15 staff members use the facilities at the various schools with a median number at 3.3.

Question 9. Do you have a physician assigned to the laboratory? Yes 3. No 13. Part time 3. Full time 0.

Question 10. How many graduate students are engaged in laboratory research work? The figure ranged between 1 and 50, with a median at 6.

Question 11. How many technicians (exclusive of graduate students) are employed in the laboratory? This number varied from 0 to 3 with a median at 1.

Question 12. Would you check the pieces of equipment listed below which you have in your laboratory?

No.[1]	*Equipment*	*No.*	*Equipment*
14	Anthropometric tape	13	Kymograph
15	Stadiometer	7	View camera
14	Depth caliper	1	Stroboscopic apparatus
14	Breadth caliper	8	Camera and equipment for sports analysis work
15	Scale	8	(1/100th sec.)
15	Hand dynamometer	9	Reaction time apparatus
14	Back and leg dynamometer	6	Tachometer
5	Muscle tensiometer	16	Stop watch
16	Spirometer	2	Tachistoscope
11	Flarimeter	12	Snellen eye chart
11	BMR apparatus	4	Flicker fusion apparatus
6	Gas analyzer	4	Keystone telebinocular apparatus
15	Stethoscope	10	Audiometer
15	Sphygmomanometer	6	X-ray equipment
3	Heartometer	7	Fluoroscope
10	Electrocardiotachometer	6	Treadmill (human)
11	Blood count equipment	9	Bicycle ergometer
12	pH meter		

[1] No. refers to the number of schools that indicated they had the apparatus listed.

Other laboratory equipment:

No.[3]	Equipment	No.	Equipment
1	Alveolar tension apparatus	2	Metronome
1	Animal exercise cage	2	Microscope
1	Anthropometric instrument	3	Muscle action potential equipment
1	Autoclave	1	Natograph
1	Brush recorder	1	Oscillograph
1	Calculator	1	Oscillometer
1	Cathode ray tube	2	Oscilloscope
2	Centrifuge	2	Oximeter
1	Chromograph	1	Pacer-in-pool apparatus
4	Colorimeter	1	Photoelectric counter
1	Cytometer	2	Plethysmograph
1	Delineascope	2	Polygraph
3	Electric counter	1	Psychogalvanometer
1	Electrocardiograph	1	Pursuit meter
1	Electrodyne	1	Seismometer
1	Electronic equipment	1	Signal generator
1	Electronic stethoscope	1	Sphygmograph
3	Ergograph	1	Sterilizer
1	Exercycle	1	Still
1	Flexometer	1	Strain gauge
1	Hackometer	1	Thermocouple
1	Heel-toe apparatus	1	Tilt table
1	Impulse counter	1	Tissot spirometer
1	Incubator	1	Van Slyke gas analyzer
1	Lactic acid analyzer	1	Ventilator chamber
1	Leap meter	1	Work meter
3	Manometer		
1	Massachusetts Vision Test		

Question 13. In which area or areas of science, as related to physical education, does the laboratory staff engage in? The following fields were listed:

No.	Field	No.	Field
2	Anatomy	1	Mechanical analysis
1	Anthropology	1	Medical physics
1	Bacteriology	5	Physics
1	Chemistry	15	Physiology
1	Child development	8	Psychology
2	Education	2	Statistics
2	Kinesiology	3	Tests and measurements

Limitations

Since the questionnaire was sent to the directors of physical education, the writer feels certain that the questions were not referred to any other department in the school. The author realizes that certain allied fields; *viz.*, medicine, physiology, psychology, education, and others do contribute rather extensively to the research work in physical education. An enumeration of the facilities of these departments does not appear in the survey.

The questionnaire was not sent to any governmental laboratory like the Human Biology Laboratory at Randolph Field, Texas, but was limited to colleges and universities. In the case of a few well-established laboratories the author did not expect to have the respondent take an exhaustive inventory of his equipment. However, it is felt that the major items were included in the replies. No attempt was made to evaluate the various pieces of equipment as to their relative importance in the establishment of a laboratory for physical education research work. The decision as to which equipment should be purchased first will, in most instances, be determined by the nature of the research project planned and the background of the worker contemplating the investigation.

Anticipated Developments

Although the primary reason for this survey was to determine the status of research facilities in Physical Education Departments at the present time, a few remarks concerning future developments could be drawn from the replies of those schools which do not operate a laboratory at the present time. The following statements concern replies from schools without laboratories:

1. In answer to Question 3 (If you do not have a laboratory at present do you have any plans for one in the future?), 35 schools indicated that they do have plans for a laboratory.
2. Twenty-six schools said that they did have money available in their budget for research work.
3. Forty-seven schools replied that their graduate students do have access to laboratory facilities in other departments for research work in physical education.
4. A number of schools indicated that they do have some equipment available for testing purposes although they did not have a laboratory.
5. It was encouraging to note the number of respondents that were interested in securing a summary of the results of the survey.

A Factor Analysis of Somatotypes and of Their Relationship to Achievement in Motor Skills

FRANK D. SILLS

State University of Iowa
Iowa City

THE PURPOSES of this study were (a) to analyze the relationships of body components to the performance of motor skills, (b) to analyze the relationship of the components endomorphy, mesomorphy and ectomorphy to one another, and (c) to analyze the relationships of these three components to a selected list of anthropometric indices.

Review of Literature

Sheldon, Stevens and Tucker (9) have presented methods for assessing body build. They have adopted the terms endomorphy, mesomorphy, and ectomorphy to indicate the three body components that are used in somatotyping (body typing). A modified list of descriptive criteria for the three components and of a fourth, introduced for the first time in this study, are as follows:

Endomorphy. Characterized by roundness and softness of body; central concentration of mass; no muscle relief; and short, tapering limbs.

Mesomorphy. Characterized by squareness and hardness of body; large bones; heavy musculature; broad shoulders with pyramiding trapezius; and broad hips with sturdy pelvis.

Ectomorphy. Characterized by linearity and delicacy of body; shoulders narrow and lacking in muscular relief; fingers and toes generally slender and long; and head may appear too large for slender neck.

Omomorphy. Characterized by wide shoulders and well developed shoulder girdle structures (skeletal and muscular); upper limbs more muscular and rugged than lower limbs; hips narrow and surrounding muscles not well developed; and torso giving an impression of having a "V shape" as a result of the dominance of the size of the upper trunk and shoulders over lower trunk and limbs. This body component was first determined by McCloy (6) in an analysis of growth factors and was originally named Factor IV. In this study the author has followed a recommendation by McCloy and used the term omomorphy.

Cozens (1) found that there were distinct differences in the general performance ability of a number of stature groups. In terms of group performances:

1. The tall were superior to the short.
2. Those of medium height were superior to the short.

3. The heavy were superior to the slender.
4. Those of medium weight were superior to the slender.
5. In the "slender" group, the tall men were superior, medium next, and the short inferior.
6. In the "medium" (weight) group the tall and medium men were superior to the shorts.
7. An insufficient number of heavy men were considered to find real differences.

Cureton (2) in a study of body build came to the conclusion that anthropometric indices are helpful in evaluating potentiality for athletic performances or for performance in organic capacity tests, but there is no established valid method of using these indices to determine body type in a manner comparable to those that relate the subjective methods with check lists. He also concluded that classifications according to constitutional type groupings may provide a framework for the understanding of health, physical fitness, and athletic performance.

In a factor analysis study, Cureton (3) isolated a factor which he named Constitutional Body Type. This factor was identified by the variables 1) somatotype physique, 2) pulse pressure, 3) posture, 4) calf girth, and 5) biceps girth. In the same study, Cureton proposed an empirical rating scale to associate somatotype ratings with performance and fitness test results.

In a study by DiGiovanna (4), the results showed marked differences between the structural and the functional measurements of various athletic groups and of a normal nonathletic group. It was significant, however, that the structural measurements which showed the most consistent differences from the normal were, for the most part, measurements that could be increased through training. Arm girth, for example, appeared as a difference in seven cases out of 11, while arm span, a relatively stable measurement, appeared in only three cases out of 11.

Jones (5) found that an ectomorph scored lower on the Brace test than a mesomorph. This observation by Jones was included in a study concerning the relationship of strength to physique in which he found that strength was related both to body size and to the mesomorphic (muscular) component in body build. He found also that mesomorphy gave a low correlation with weight and a negative correlation with height.

In a factor analysis study, McCloy (6) found five factors of physical growth which he identified as growth in fat, general growth, growth in cross-section, "Factor IV" (most prominent in chest measurements and shoulder width), and neural growth. In an earlier study (7) concerning body build relative to physical status, McCloy found that distribution of body build indices followed approximately the normal curve. The two indices chest circumference $\div$ height and $\sqrt[3]{\text{normal weight}} \div$ height were the body type indices used in that study.

The use of factor analysis in physical education research was studied by Emma McCloy (8). She concluded that this method of research had certain limitations but should be useful in the solution of problems that

have baffled research workers in physical education. Thurstone's multiple factor analysis method gave the best results and was adopted for the present study.

Procedure

The collection of data, with the exception of six tests, for the factorial analysis was made by the author and two graduate students at the State University of Iowa. One hundred and fifty-eight subjects were measured, tested, and somatotyped. The average age of the group was 18 years and six months. All subjects were members of the freshman class and were participants in the basic skills course in physical education.

Test Battery

A battery of 16 tests was administered to the subjects. In every case, the tester gave an explanation and/or a demonstration of the test being administered. Preliminary practice was given in the events that required such a procedure. An effort was made to include tests of strength and speed so that a strength factor and a speed factor would be determined. This procedure was followed to facilitate the interpretation of the final factor loadings. The Iowa Brace and the dodge run were included for exploratory purposes. It was believed that their positions in the geometric configurations of the isolated factors might prove useful in future studies.

Six of the tests were administered by the physical-education faculty at the beginning of the academic year 1947–48. Included in this group were sit-ups (two minutes), pull-ups, squat thrusts (20 seconds), squat jumps, 100-yard pick-a-back run, and 300-yard shuttle run. The remaining tests, which included a number of parallel bar dips, hand grips, leg lift, back lift, Sargent jump, dodge run, 60-yard dash, eight-pound shot, standing broad jump, and the Iowa revision of the Brace test, were all administered by the author and his two assistants.

Anthropometric Measurements

The following 22 anthropometric measurements were taken by the author on each subject: (a) weight, (b) height, (c) height to trochanterion, (d) sitting height to cervicale, (e) arm length acromion to stylion, (f) bi-acromial shoulder width, (g) chest depth, (h) chest width, (i) bi-iliac width, (j) elbow width, (k) knee width, (l) neck girth, (m) chest girth, (n) waist girth, (o) arm girth, (p) forearm girth, (q) thigh girth, (r) calf girth, (s) fat chest front, (t) fat chest back, (u) fat abdomen, and (v) fat supra-iliac.

For statistical purposes, height and weight were included in raw score form, while the remaining measurements were either utilized as indices or dropped from this analysis entirely. On the basis of their probable relationship to the three body components, the following indices were computed and included in the correlation matrix: (a) thigh girth ÷ knee width, (b) waist girth ÷ bi-iliac width, (c) sum of fat measurements ÷ height, (d) shoulder width ÷ height, (e) chest girth ÷ height, (f) arm length ÷

arm girth, (g) sum of knee and elbow joints ÷ height, (h) shoulder width ÷ bi-iliac width.

Photography and Somatotyping

In *The Varieties of Human Physique* (9) the authors have presented instructions for photography in respect to somatotyping. In the present study, the photographic techniques employed were designed to achieve results similar to those of Sheldon and his co-workers at a lower cost. A Leica III C camera with an f3.5 Elmar lens was used to photograph all subjects. Panatomic X film was used, the exposure time was set for $\frac{1}{10}$ second and the lens was stopped down to f6.3. Considerable preliminary experimentation was carried out under the direction of Dr. Arthur J. Wendler of the University of Iowa before the photography was considered satisfactory for somatotyping.

An effort was made to conform to the recommendations of Dupertuis and Sheldon[1] for the lighting and the posing of the subject. The subject and the background were both lighted in a manner that minimized or eliminated all shadows. The background consisted of a white cloth screen with vertical black lines at sixteen inch intervals and horizontal lines at twelve inch intervals. The author served as poser for the 158 subjects who were photographed.

Explanatory diagrams that are intended to clarify the photographic plan are to be found in Figures 1 and 2. Important measurements in reference to the plan follow:

Camera to screen	150 inches
Camera to subject	120 inches
Height of camera[2]	38 inches
Background lights to screen	20 inches
Diameter of pedestal	18 inches
Height of pedestal	6 inches
Height of lower photoflood	24 inches
Height of upper photoflood	54 inches
Height of lower background bulb	10 inches
Height of upper background bulb	80 inches
Interval between background bulbs	14 inches

Somatotyping. The somatotyping involved an evaluation of each subject in terms of the criteria set forth by Sheldon, Stevens, and Tucker (9). Reliability was established by having three members of the physical-education faculty examine and type each individual on the basis of a front, side, and back view. The correlations between the judges' ratings were .917 for endomorphy, .904 for mesomorphy, and .946 for ectomorphy. The ratings were made on the basis of a 13 point scale with the bottom of the scale set at one and the top at seven. When an individual was considered average, he was given a score of four. The component omomorphy was rated on a similar scale by McCloy (6).

[1] Personal communication, Dr. C. W. Dupertuis and Dr. W. H Sheldon.
[2] All heights are in reference to the distance from the floor.

Although secondary variables were not rated, they were frequently observed and commented upon by the judges. It should be noted that for the practical application of somatotyping techniques in physical education, these secondary variables would have to be considered in an appraisal of the individual. In the absence of an evaluation of such variables as dysplasia and gynandromorphy, for example, it would be possible to include

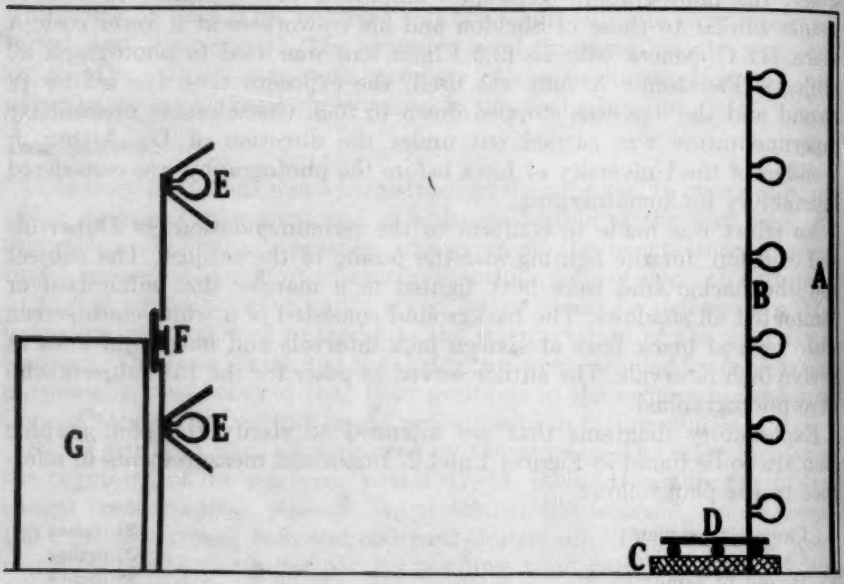


FIGURE 1. Side View of Photographic Plan
A—Background screen
B—Background lighting
C—Pedestal base
D—Pedestal
E—Subject lighting
F—Camera
G—Photographer's stand

individuals in the same classification who would be vastly different in respect to physical performance of motor skills.

Rather than enter into an extended discussion of somatotyping, the author refers the reader to Sheldon, Stevens, and Tucker (9). Since evaluative criteria for omomorphy have not been published, however, it was decided that the following list should be included.

CHECK LIST FOR OMOMORPHY

1. Upper body developed out of proportion to lower body. General appearance of V-type build
2. Width of shoulders dominant over width of hips

3. Chest width dominant over chest depth
4. Well developed pectoral muscles
5. Narrow waist and hips
6. Legs slender and not heavily muscled
7. Prominent deltoid muscling and pyramiding of trapezius
8. Bony framework of shoulder girdle more prominent than that of the hip girdle

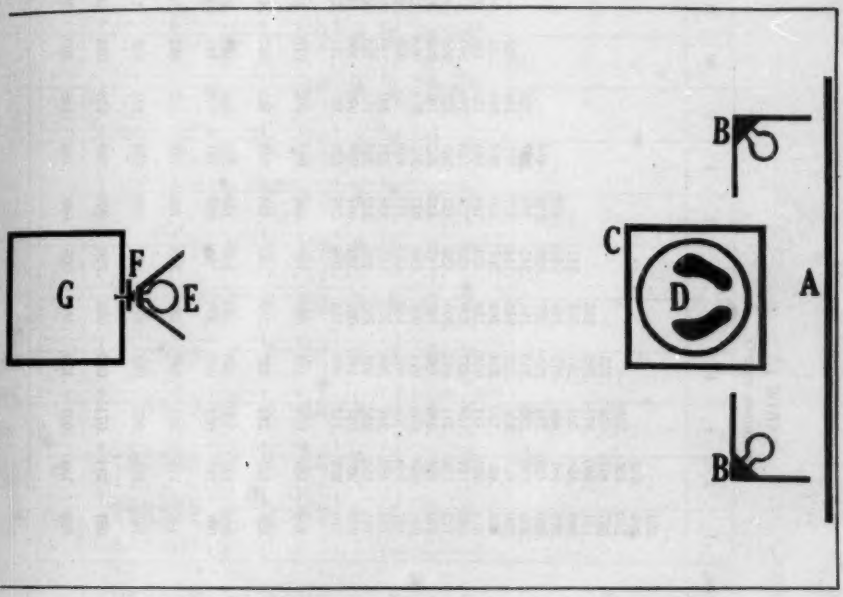


FIGURE 2. Top View of Photographic Plan
A—Background screen
B—Background lighting
C—Pedestal base
D—Pedestal
E—Subject lighting
F—Camera
G—Photographer's stand

9. Neck width dominant over anteroposterior diameter
10. Arms proportionately greater in circumference than legs

Factorial Analysis

Thirty variables were placed in the correlation matrix. Preliminary investigations of the variables and their intercorrelations were made from the results of previous studies and from small samples taken from the present study. This procedure was followed in an effort to utilize the best possible combinations of variables with the hope that a well-defined analysis could be obtained.

TABLE 1

Correlation matrix

NAME OF TEST	NO. OF VAR.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Squat Jumps	1	—														
300 Yard Run (shuttle)	2	.504	—													
100 Yard Pick	3	.389	.643	—												
Sit-ups (2 min.)	4	.280	.423	.330	—											
Sargent Jump	5	.327	.437	.436	.213	—										
8 Pound Shot	6	.131	.260	.275	.225	.236	—									
Standing Broad Jump	7	.348	.554	.525	.231	.510	.341	—								
60 Yard Dash	8	.269	.687	.559	.372	.386	.353	.470	—							
Dodge Run	9	.280	.419	.281	.280	.207	.323	.316	.414	—						
Squat Thrust (20")	10	.333	.320	.285	.265	.191	.245	.258	.257	.225	—					
Pull Ups	11	.350	.493	.386	.313	.345	.114	.377	.377	.246	.155	—				
Dips (parallel bars)	12	.306	.427	.320	.234	.266	.207	.330	.383	.346	.132	.467	—			
Combined Hand Grips	13	−.014	.024	.121	−.016	.158	.404	.168	.184	.156	.289	−.008	.152	—		
Leg Lift	14	.126	.121	.168	.037	.570	.432	.739	.152	.216	.201	.118	.100	.357	—	
Back Lift	15	.112	.126	.211	−.015	.073	.533	.197	.260	.227	.205	.081	.143	.528	.558	—
Brace Test (Iowa)	16	.370	.325	.285	.185	.367	.141	.442	.231	.191	.296	.370	.231	.053	.083	.049
Height	17	.011	.050	.039	−.014	−.005	.288	.047	.009	−.014	−.068	−.320	−.095	.193	.128	.280
Weight	18	−.137	−.344	−.108	−.162	−.166	−.450	−.152	−.195	−.193	.030	−.426	−.265	.386	.358	.464
Endomorphy	19	−.165	−.462	−.249	−.208	−.272	.158	−.338	−.234	−.291	−.040	−.359	−.261	.145	.152	.163
Mesomorphy	20	.181	.194	.253	.103	.285	.403	.242	.204	.211	.195	.320	.307	.303	.259	.331
Ectomorphy	21	.010	.200	.027	.146	.031	−.332	.087	.050	.074	−.100	.063	−.012	−.288	−.314	−.317
Thigh Girth	22	−.216	−.329	−.112	−.100	−.113	.190	−.198	−.122	−.137	.134	−.297	−.205	.210	.158	.196
Knee Width Waist Girth	23	−.169	−.154	−.074	−.115	−.030	.185	−.106	−.051	−.092	.010	−.171	−.079	.129	.073	.177
Bi-iliac Width Sum of Fats	24	−.306	−.531	−.255	−.229	−.280	.100	−.404	−.319	−.303	.027	−.413	−.271	.135	.115	.163
Height Omomorphy	25	−.005	.115	.130	.190	.154	.225	.128	.218	.166	.198	.270	.273	.290	.034	.236
Shoulder Width	26	−.001	−.198	−.051	−.002	−.380	.158	−.080	−.131	−.018	.249	.006	−.052	.269	.198	.181
Height Chest Girth	27	−.140	−.315	−.091	−.088	−.131	.288	−.166	−.148	−.182	.092	−.152	−.091	.256	.267	.329
Height Arm Length	28	.140	.361	.067	.083	.077	−.235	.199	.133	.131	−.043	.110	.035	−.323	−.268	−.290
Arm Girth Sum of Joints	29	.067	−.234	−.071	−.082	−.059	.229	.004	−.158	−.139	.026	−.060	−.011	.214	.204	.277
Height Shoulder Width	30	.039	.188	.097	.132	.160	.005	.098	.184	.148	.200	.206	.088	.144	−.035	.030
Bi-iliac Width																

NAME OF TEST	NO. OF VAR.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Brace Test (Iowa)	16	—														
Height	17	−.095	—													
Weight	18	−.243	.422	—												
Endomorphy	19	−.245	−.045	.688	—											
Mesomorphy	20	.095	−.204	.193	−.035	—										
Ectomorphy	21	.145	.281	−.608	−.667	−.719	—									
Thigh Girth	22	−.182	−.089	.584	.704	.174	−.619	—								
Knee Girth Waist Girth	23	−.152	−.155	.445	.489	.249	−.515	.540	—							
Bi-iliac Width Sum of Fats	24	−.339	−.151	.653	.794	.067	−.639	.679	.616	—						
Height Omomorphy	25	.137	−.220	.001	−.075	.474	−.201	.107	.146	.008	—					
Shoulder Width	26	−.022	−.256	.265	.260	.307	−.412	.318	.244	.370	.380	—				
Height Chest Girth	27	−.165	−.201	.691	.665	.343	−.752	.630	.564	.759	.236	.408	—			
Height Arm Length	28	.198	.216	−.635	−.743	−.403	.816	−.715	−.509	−.708	−.223	−.405	−.734	—		
Arm Girth Sum of Joints	29	−.038	.012	.498	.409	.274	−.498	.190	.282	.400	.004	.326	.494	−.418	—	
Height Shoulder Width Bi-iliac Width	30	.133	−.248	−.237	−.217	.233	.026	−.016	.338	−.110	.379	.479	−.091	.013	−.078	—

The range of variation of the 158 students who served as subjects was not as great as to roundness, muscularity, and linearity as the author had desired. The number of extreme cases, particularly of mesomorphy and endomorphy, was definitely limited in the population from which the sample was drawn.

Six sets of factor loadings were determined. The residuals from the sixth factor were considered too small to be significant. The sixth factor was plotted and used in rotation but could not be identified, indicating from its relationship to the first five that it was a residual factor.

The unrotated factor loadings for the six factors are tabulated in Table 2. The communalities are given in the last column of this table and indicate the common factor variance of the variables included in the battery. It is evident that a considerable part of the variance of a number of the tests (Table 2) is not accounted for in the present analysis. This does not indicate that the inclusion of these tests was unwarranted since they do appear to be significant in their relationship with some of the factors. On the basis of this evidence it would be advisable to add tests of a similar nature in a future study of body types and/or motor skills in an effort to identify new factors.

Interpretation of Factor Loadings

FACTOR I: ENDOMORPHY

In Table 3 the rotated factor loadings are tabulated. The sum of the fat measurements ÷ height (.917), endomorphy (.846), chest girth ÷ height (.810), thigh girth ÷ knee width (.796), weight (.783), and waist girth ÷ bi-iliac width (.647) in the order given have the highest loadings on Factor I, *Endomorphy*.

The identification of this factor is dependent, primarily, upon anthropometric indices. The fact that the majority of the motor ability tests appear as negative loadings serves to substantiate the theory that endomorphy (or overweight) bears a negative relationship to performance in these tests.

In examining the loadings for Factor I it is evident that this factor is bipolar (a factor with positive and negative saturations). It is interesting to note that ectomorphy is at the opposite extreme from endomorphy. The position of these two body components may be interpreted as meaningful and not merely a geometric consequence of the location of the first axis in the middle of the test configuration (10).

Mesomorphy has a slight positive loading on endomorphy; thus, for Factor I endomorphy is opposite to ectomorphy with mesomorphy unrelated.

FACTOR II: STRENGTH

The identification of this factor is readily made from the following loadings: (a) leg lift (.830), (b) back lift (.657), (c) standing broad jump (.586),

TABLE 2

Unrotated Factor Loadings (The Factor Matrix)

NAME OF TEST	NO. OF TEST	I	II	III	IV	V	VI	h^2
Squat Jump	1	.296	.441	.178	−.177	−.293	−.293	.461
300 Yard Run	2	.310	.733	.224	.127	−.192	−.075	.742
100 Yard Pick-a-back	3	.427	.497	.192	.051	−.227	−.065	.525
Sit-ups (2 min.)	4	.247	.409	.033	.142	−.139	−.085	.275
Sargent Jump	5	.358	.456	.236	−.303	−.126	.327	.607
Eight Pound Shot Put	6	.610	−.056	.397	.142	.088	−.047	.563
Standing Broad Jump	7	.431	.487	.426	−.276	.135	.177	.729
60 Yard Dash	8	.420	.530	.164	.217	−.143	.137	.570
Dodge Run	9	.290	.404	.147	.146	.104	.077	.307
Squat Thrust (20″)	10	.438	.201	.095	.172	−.137	−.093	.299
Pull-ups	11	.308	.605	−.180	−.214	.120	−.031	.554
Parallel Bar Dips	12	.330	.447	−.040	−.084	.133	.049	.338
Combined Hand Grips	13	.492	−.151	.223	.175	.254	.084	.418
Leg Lift	14	.572	−.080	.460	−.329	.222	.282	.782
Back Lift	15	.558	−.187	.388	.129	.268	.073	.586
Iowa Rev. of Brace	16	.230	.460	.079	−.143	−.029	−.030	.293
Height	17	−.134	−.132	.691	.244	.062	−.113	.589
Weight	18	.377	−.789	.367	.079	−.087	−.167	.942
Endomorphy	19	.217	−.794	−.055	−.077	−.343	.138	.823
Mesomorphy	20	.675	.065	−.231	−.126	.227	−.209	.625
Ectomorphy	21	−.662	.530	.298	.281	.068	.184	.926
Thigh Girth / Knee Width	22	.405	−.608	−.175	.126	−.308	.176	.707
Waist Girth / Bi-iliac Width	23	.418	−.425	−.300	.165	−.136	.187	.526
Sum of Fats / Height	24	.281	−.808	−.228	.046	−.247	.042	.849
Omomorphy	25	.455	.150	−.317	.200	.267	.055	.444
Shoulder Width / Height	26	.414	−.270	−.327	.226	.333	−.228	.565
Chest Girth / Height	27	.552	−.645	−.194	−.084	−.129	−.063	.787
Arm Length / Arm Girth	28	−.572	.626	.285	.119	.097	−.075	.829
Sum of Joints / Height	29	.359	−.410	.042	−.259	.093	−.265	.445
Shoulder Width / Bi-iliac Width	30	.262	.240	−.340	.382	.223	.102	.449

(d) eight pound shot put (.583), and (e) combined hand grips (.489). Weight, height, and the Sargent jump have fairly high positive loadings. These variables have been established, relative to strength, in a previous study (11) and it is unnecessary to discuss them in further detail.

TABLE 3

Rotated Factor Loadings

NAME OF TEST	NO. OF TEST	I	II	III	IV	V	VI	h^2
Sum of Fats	24	*.917*	.026	.083	.020	.066	.011	.853
Height Endomorphy	19	*.846*	.144	.049	.057	−.146	.231	.817
Chest Girth	27	*.810*	.168	(.359)	.043	.192	.204	.782
Height Thigh Girth	22	*.796*	.099	.069	.217	.127	.012	.711
Knee Width Weight	18	*.783*	(.493)[a]	−.018	.073	.027	−.288	.945
Waist Girth	23	*.647*	.026	.099	.141	.293	.021	.535
Bi-iliac Width Leg Lift	14	.020	*.830*	.266	−.032	−.005	.166	.789
Back Lift	15	.236	*.657*	.014	.073	(.327)	.031	.600
Standing Broad Jump	7	−.510	*.586*	.278	.190	.000	.029	.733
Eight Pound Shot	6	.149	*.583*	.114	.288	.292	−.161	.565
Comb. Hand Grips	13	.106	*.489*	.007	.068	(.376)	−.145	.416
Height	17	−.046	*.407*	−.453	.001	−.132	−.442	.594
Sargent Jump	5	−.427	*.386*	.284	(.300)	−.126	.302	.609
Mesomorphy	20	.137	.173	*.596*	.015	(.474)	−.011	.629
Pull-ups	11	−.493	−.015	*.463*	.096	.195	.220	.553
Squat Jump	1	−.386	.110	*.411*	(.348)	−.044	.082	.459
Sum of Joints Height	29	(.410)	.268	*.377*	−.150	.058	.212	.452
Dips	12	−.347	.124	*.289*	.125	.222	.214	.330
Iowa Rev. Brace	16	−.414	.107	*.275*	.213	.025	.045	.305
300-Yard Run (Shuttle)	2	−.599	.100	.109	*.594*	.113	−.029	.746
60-Yard Dash	8	−.349	.200	.081	*.550*	.233	.195	.563
100-Yard Pick-a-Back	3	−.348	.177	.254	*.547*	.104	−.018	.527
Squat Thrust (20″)	10	−.207	.157	.062	*.452*	.172	−.055	.308
Sit-ups (2 min.)	4	−.272	−.007	.135	*.386*	.160	−.026	.268
Shoulder Width Height	26	.358	−.013	.198	−.147	*.603*	−.105	.562
Omomorphy	25	.079	.014	.205	.018	*.581*	.231	.440
Shoulder Width Bi-iliac Width	30	−.012	−.144	−.016	.093	*.576*	.273	.442
Dodge Run	9	−.313	.209	.042	.243	*.252*	.187	.300
Ectomorphy	21	−.712	−.163	−.604	.025	−.218	−.016	.933
Arm Length Arm Girth	28	−.809	−.176	−.374	.000	−.017	−.023	.824

[a] Loadings in parentheses are significant in the identification of more than one factor.

In respect to the other variables, the sum of the joint widths ÷ height and chest girth ÷ height respectively are the indices with the highest

loadings on Factor II. The former index is generally related to the more rugged type of body build. It is logical, therefore, that this index should correlate with *Strength*. The latter index is typical of a fairly large body type that would also be expected to correlate with *Strength*. The remaining indices show no appreciable relationship to Factor II.

Mesomorphy, endomorphy, omomorphy, and ectomorphy range from a low positive loading (.173) to a low negative loading (−.163) in the order named. These loadings indicate that somatotype ratings are of little discriminatory value in respect to strength.

FACTOR III: MESOMORPHY

The fact that the body component of mesomorphy appears as the highest loading on this factor axis serves as a basis for naming the factor *Mesomorphy*. It is interesting to observe that the five highest loadings (none is above .463 with the exception of mesomorphy) include both motor tests and anthropometric indices. With the exception of weight, the preceding factors were identified by a cluster of either the one (anthropometric indices) or the other (motor tests). The motor tests that have the highest loadings on this factor are primarily tests of strength (pull-ups and dips), endurance (pull-ups and squat jumps), and power (Sargent jump and standing broad jump). These tests with high loadings are of a different nature from those with high loadings on Factor II, which were primarily dynamometric strength tests.

It is also interesting to observe the location of the endomorphic and ectomorphic variables on this factor. Ectomorphy has a high negative loading, thus making it negative on both Factors I and III. Endomorphy has a low positive loading which indicates that it is practically unrelated to *Mesomorphy*. The variable omomorphy has a positive loading of .205 indicating some degree of relationship to *Mesomorphy*.

One of the anthropometric indices which appears high on *Mesomorphy* is the sum of the joints ÷ height. This occurrence follows logically a descriptive criterion for mesomorphy. A mesomorph is partially identified on the basis of having a strong skeletal structure.

Chest girth ÷ height has the second highest positive loading of the indices. This index had a high loading on *Endomorphy* but is also high enough on Factor III to be considered significant.

FACTOR IV: POTENTIAL CONTRACTION SPEED OF MUSCLE (PCSM)

The 300 yard run (.594), 60 yard dash (.550), and 100 yard pick-a-back (.547) have the highest loadings on *PCSM*. By inspecting Table 3, it may be observed that the majority of the motor skills tests are represented by positive loadings. Since performance in these tests is partially dependent upon speed of movement, their relationship to this factor is readily understood. The positions of these tests on Factor IV are quite similar to those established in earlier studies. An excellent analysis of this factor (Speed) may be found in an article written by Wendler (11).

The four somatotype variables are all represented by very low loadings indicating little or no relationship with Factor IV. The loadings for the anthropometric indices are also low and of little significance.

In the study by Wendler, mentioned above, speed and strength were found to be unrelated. The speed factor in the present study has low loadings for all of the strength tests substantiating the findings of this former study.

FACTOR V: OMOMORPHY

Two anthropometric indices $\left(\frac{\text{shoulder width}}{\text{height}}\right)$ and $\left(\frac{\text{shoulder width}}{\text{bi-iliac width}}\right)$, that were derived from the descriptive criteria, and the body component rating itself serve to identify Factor V.

It is interesting to compare the saturations of motor tests on this factor (omomorphy) and on the third factor (mesomorphy). Those tests which require greater strength throughout the body appear higher on *Mesomorphy* than on *Omomorphy*, while tests requiring strength of the upper body give higher loadings on Factor V. Pull-ups are an exception, since they have a loading more than twice as great on *Mesomorphy* (.463 compared to .195). Back lift has a higher loading on *Omomorphy* than on *Mesomorphy*, while the reverse is true in respect to leg lift. This fact is readily explained since an omomorph has relatively small legs in proportion to his upper body strength.

In all jumping events, the factor loadings on *Omomorphy* are near zero. The dominance of upper body over lower body probably accounts for the positions of these loadings.

Ectomorphy has a small negative loading (−.218) on Factor V and mesomorphy has a fairly high (.474) positive loading. The position of these loadings does not agree with Sheldon, Stevens, and Tucker's interpretation in *The Varieties of Human Physique* (page 39) of wide shoulders and narrow hips as a combination of mesomorphy and ectomorphy.

Conclusions

1. The body components endomorphy, mesomorphy, and omomorphy were identified as discrete factors. Ectomorphy was not identified as a separate factor, but as a negative aspect of endomorphy and mesomorphy.
2. The motor ability tests had positive loadings on mesomorphy and omomorphy; however, they were significant in respect to endomorphy only as indicated by negative loadings.
3. The strength factor found in this factor analysis had no significant loadings in respect to the body components endomorphy, mesomorphy, ectomorphy, and omomorphy.
4. The speed factor was identified by motor ability tests and the somatotype loadings were not significant.
5. On the basis of their relative positions on the factors *Mesomorphy*

and *Omomorphy* the somatotype ratings for mesomorphy and omomorphy appeared to be related to one another.

6. The present study fails to identify ectomorphy as a discrete factor. The negative position of ectomorphy on the factors *Endomorphy* and *Mesomorphy* raises a question in respect to the Sheldon, Stevens, and Tucker interpretation of the functional independence of the body components. Since stockiness of build is generally accepted as the opposite of linearity in build, it appears that this characteristic may be associated with both endomorphy and mesomorphy; thereby making ectomorphy a reciprocal of both endomorphy and mesomorphy.

7. The use of anthropometric indices proved useful in identifying the factors *Endomorphy and Omomorphy;* however, the indices were of little value in the identification of the other factors.

Suggestion for Further Study: The relationship of body type to performance in specialized forms of activity.

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A uniform sequence of data should be observed. The preferred sequence is: Author's name—title of article or chapter—name of book or publication —volume number—page numbers—year date.

EXAMPLE OF FOOTNOTE

[3] H. Harrison Clarke. *The Application of Measurement to Health and Physical Education.* New York: Prentice-Hall, Inc., 1946. p. 240.

EXAMPLE OF REFERENCES APPEARING AT END OF ARTICLE

1. OGDEN, JEAN, AND OGDEN, JESS, *Small Communities in Action.* New York City: Harper & Brothers, 1946. (books)

1. DEAVER, G. G. Exercise and heart disease. *Research Quarterly,* **10**:24–34, 1939. (periodicals)

or

2. DEAVER, G. G., "Exercise and Heart Disease," *Research Quarterly* **10**:24–34 (1939). (periodicals)

Use of Numbers

Use figures for all definite weights, measurements, percentages, and degrees of temperature (for example: 2 kgm., 1 inch, 20.5 cc., 300°C.). Spell out all indefinite and approximate periods of time and other numerals which are used in a general sense (for example: one hundred years ago, about two-and-one-half hours, seven times). Spell out numbers through nine; arabic figures for 10 and over.

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The metric system being in universal usage, standard abbreviations should be used whenever the weights and measurements are used with figures, i.e., 10 kgm., 6.25 cc., etc. The forms to be used are: cc., kgm., mgm., mm., l., and m. *Gram* should be spelled out in all cases to avoid possible confusion with grain. All obscure and ambiguous abbreviations should be

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Continued from October Quarterly

RESEARCH ABSTRACTS

Prepared by the Research Abstracts Committee of the Research Section, Carolyn W. Bookwalter, Chairman

Anatomy and Physiology

61. POLLOCK, L. J., A. ARIEFF, I. SHERMAN, M. SCHILLER, E. TIGAY, F. HILLER, E. LIEBERT, AND G. YACORZYNSKI. The effect of massage and passive movement upon the residuals of experimentally produced section of the sciatic nerves of the cat. *Arch. Physic. Med.*, **31**(5): 265–276 (1950).

Sciatic nerve in a number of cats was severed and then sutured. After this the animals were divided into two groups. One received massage and passive movements, the other no treatment. Although there was no statistically significant difference in the amount of muscle atrophy in both groups, the investigators observed that the treatment retarded the development of contractions and facilitated their disappearance. They also think that the treatment used resulted in a better neurotization of the distal segment of the nerve.—*P. V. Karpovich.*

62. REYNOLDS, EARLE LANDRY AND TOSHILO ASAKAWA. A comparison of certain aspects of body structure and body shape in 200 adults. *Am. J. Phys. Anthrop.*, n.s. **8**: 3 (September, 1950).

Measurements were taken of breadths of fat, muscle, and bone, as seen in roentgenograms of the leg in 100 men and 100 women, ages 19 through 70 years. Weight, height, leg size, photographs, and assessments of androgyny (Baley and Bayers) and somatotype (Sheldon) were taken. Intercorrelations between tissue breadth are low. Correlations of tissue breadth with weight are significant, but not with height. Bone breadth shows least relation to weight and most to height. Age is not a factor in present series, as measured by correlation. Men have significantly more muscle and bone than women, and less fat, and sex differences in tissue distribution are much more significant than is total breadth of calf. Marked deviations in tissue distribution are associated with unusual patterns of body shape. Individuals with a tissue distribution of the opposite sex have a body shape more similar to the opposite sex. There is a close association between the distribution of the fat/bone index and masculine-femininity aspects of body shape as measured by androgyny scores. When somatotypic extremes are compared, endomorphs are heaviest in weight, with lowest ponderal index, thickest legs, most fat and relatively least bone and muscle. Mesomorphs are intermediate in size, with largest bones and relatively largest muscles. Ectomorphs are lightest in weight, with highest ponderal index and least fat, muscle and bone; they have the relatively thickest bones.—The Wistar Institute.

63. RICHARDSON, A. W., C. IMIG, G. FEUCHT, AND H. HINES. The relationship between deep tissue temperature and blood flow during electromagnetic irradiation. *Arch. Physic. Med.*, **31**(1): 19–25 (1950).

Application of short wave diathermy may or may not increase the blood flow in the treated area. It all depends on the amount of heat developed in the tissues. It was necessary, for instance, to raise the temperature in a dog's leg to 44 C. in order to obtain a consistent increase in the flow of the blood in the femoral artery. Although the increased blood flow subsequently lowers the temperature of the surrounding tissues, the increased flow nevertheless persists for as long as 30 minutes after irradiation.—*B. V. Karpovich.*

64. SALVATORE, CARLOS ALBERTO. The growth of human myometrium and endometrium (studies of cytological aspects). *Anat. Rec.*, **108:** 1 (September, 1950).

By applying the karypmetric statistical method to the study of the changes in nuclear volumes of human uterine muscle during the menstrual cycle and pregnancy, and to the study of the changes in nuclear volumes of human endometrium during the phases of the menstrual cycle, one finds: Rhythmical variations of nuclear volume of human muscle cells occur during the menstrual cycle, indicating the existence of nuclear interphasic growth stages. During gestation, histograms show the presence of nuclear volumes which are multiples of those found during the menstrual cycle. The average modal values in these histograms have the following ratios: 77.7:114.2:160.6:219.4 and 281.7 μ^3, or approximately 1:1.5:2:3 and 4.

Endometrial growth during the proliferative phase is accompanied by nuclear interphasic growth cycles. These nuclei, which initially have an average volume of 129 μ^3, pass through an intermediate stage of 182 μ^3 and after doubling their original volume (255 μ^3) undergo division. During the secretory phase, the nuclei have a volume approximating the intermediate stage of their interphasic growth, i.e. 1.5 times the basic volume or an average of 182 μ^3, and mitoses of the endometrium are completely absent.—*The Wistar Institute.*

65. WILLIAMS, ROY GRIFFIN AND BROOKE ROBERTS. An improved tantalum chamber for prolonged microscopic study of living cells in mammals. *Anat. Rec.*, **107:** 4 (August, 1950).

An improved tantalum and mica chamber is described which when installed in a rabbit's ear permits microscopic studies of cells and tissues for a period of years. Directions are given for constructing and installing the device and adapting it for exposing the tissue to solutions of unknown composition.—*The Wistar Institute.*

Education

66. BOWYER, VERNON. Teachers' salaries compared with capital outlay. *School and Society*, 72, 1864: 169–171 (September 9, 1950).

Data on expenditures were taken from the *Biennial Survey of Education* and from statistics on state school systems set up by the U. S. Office of Education for 1929–1947. The changes in per capita income correlated .72 with the per cent of expended income for teachers' salaries. A relationship of .57 was found between per capita income and value of school property.—*Carolyn W. Bookwalter.*

67. JONES, MARY COVER AND NANCY BAYLEY. Physical maturity among boys as related to behavior. *J. Educational Psychology*, **41:** 129 (March, 1950).

Two groups of boys were selected for this experiment, on the basis of physical maturity as assessed by skeletal x-rays.

The two groups fell at opposite ends of a normal sample of boys. The groups were

compared on physical characteristics, social behavior as measured by rating scales, clubhouse records, and reputation with classmates.

The general picture revealed of the two groups indicates that boys who are physically accelerated are much more mature in their behavior than the physically retarded boys. The accelerated boys become leaders and are readily accepted by the group while many of the retarded boys show evidence of maladjustment.—*Marjorie Phillips.*

68. SCHMID, JOHN JR. Factor analysis of prospective teacher's differences. *J. Experimental Education*, **18:** 287 (June, 1950).

The primary purpose of this investigation was to determine what the basic factors are that underlie certain measures of teaching efficiency. The tests included twenty-four variables; seven from the Washburne Social Adjustment Inventory, seven from the Mooney Problem Check List, four from the Minnesota Multiphasic Personality Inventory, and six personal data measures.

Applying the factor analysis technique four common factors emerged from the analysis of the female subjects and two common factors from the analysis of the male subjects. The factor patterns for the two sexes were quite different. The four factors from the female subjects are: 1. Problems Response Set. 2. Professional Maturity. 3. Introversion. 4. Social Adjustment. The two factors located for the male subjects are: 1. Social & Educational Adjustment. 2. Personality—Psychological Factor.—*Marjorie Phillips.*

Health and Safety

69. BOYD, L. Serologic Tests for Cancer. *N. Y. State J. of Med.* **50:** 18 (Sept. 15, 1950).

Past and present cancer detection tests are discussed briefly, and evaluations made. 'Apart from cytologic methods, none of the new tests in their present form is suffi-'ciently specific or sensitive to warrant serious consideration as a detection test for cancer. . . ." However, these tests should be investigated as they "may provide significant information of a new order concerning metabolic abnormalities in disease," entirely apart from the study of cancer.

"Thermal coagulation of serum proteins" has been shown to give false findings (both positive and negative) and evidence indicates that it is not a "'cancer test' at all". In short, there is no "reliable serologic test for screening patients for the early detection of cancer" at present.—*A. C. Kelly.*

70. FORSYTHE, C. E. Statistically speaking. *J. School Health*, **20:** 6 (June, 1950).

This article is a reprint from Safety Education (March, 1950).

The study was made by the Michigan High School Athletic Association, the Minnesota State High School League, and the Wisconsin Interscholastic Athletic Association and ascertains the kinds of injuries received in high school football. Data was tabulated and compiled from the Athletic Accident Benefit plan for these states.

Findings include: There is a greater incidence of injuries, proportionately, in regular games than in practice situations; running plays are the most hazardous type; tacklers and blockers are more prone to injury than players being tackled or blocked; dental, face and nose injuries are the most common injuries during a football game; shoulder girdle and collar bone areas are vulnerable to injury; unless football pants fit snugly, so that knee pads which are a part of the pants are held in place, it seems desirable for players to wear separate knee pads which can be securely fastened; since pelvic injuries are among the most serious in football, it is most important that

hip pads have enough padding and fit the wearer properly; and properly fitting equipment cannot be overemphasized.—*John H. Shaw.*

71. Gray, J. Stanley and Paul Prevetta. Fluorescent light versus daylight. *Journal of Applied Psychology.* 34, **4:** 235, 236 (August, 1950).

Fifty subjects were tested by means of the American Optical Company's Sight Screener to measure the effects of two hours of continuous reading by daylight as compared to reading for the same length of time under fluorescent lights. Books set in eight point type and light intensity of 20 foot-candles were used. In all cases the light source was behind and above the subjects.

The authors concluded that fluorescent light of 20 foot-candles intensity is not inferior to daylight of the same intensity for reading eight point type material for two hours duration.—*Carolyn W. Bookwalter.*

72. Litchfield, H., Norton, R., and Hoffman, C. Experimental Study of a Synthetic Breast Milk for Infant Feeding Formula. *N. Y. State J. of Med.* **50:** 17 (Sept. 1, 1950).

From May 1948 through winter 1949, 171 newborn infants were fed a formula of a powdered synthetic breast milk. Bremil. At first weight increase was slow, but after the mineral content was increased, the birth loss was regained by the fourth or fifth day in most cases, and practically always by the sixth day.

Growth curves of these unselected infants, fed exclusively on Bremil, closely resembled those of infants fed on breast milk, and in some instances were better. The composition of the synthetic milk is similar to that of breast milk, but the synthetic product has the advantage of "uniformity". Babies fed on this uniform product were less liable to gastrointestinal upsets than the pure breast-fed babies, "affected by the mother's daily emotional or physical upsets and diet." The "powdered synthetic breast milk is advocated for continued use up to the first year, or longer if desired. . . ."—*A. C. Kelly.*

73. Snyderman, Selma Eleanore, Luther Emmett Holt, Jr., Rosa Lee Nemir, Loren Pritchard Guy, Rosario Carretero, and Katherine Creasy Ketron. Observations on an unknown dietary essential for human growth. *Journal of Nutrition,* **42:** 1 (September, 1950).

A deficiency syndrome which occurs after prolonged feeding of a purified ration in which all the vitamins are supplied as synthetic supplements is described. The syndrome consists of weight gain unaccompanied by any other symptoms or signs. A normal infant diet brings about an immediate weight gain; supplementation with brewers' yeast also has a beneficial effect after a preliminary lag period of 10 to 28 days.

The existence of an unknown factor contained in the normal diet and necessary for human growth has been recognized, this factor may be identical with vitamin B_{12} or the "animal growth factor"; whether or not it is, remains to be seen.—*The Wistar Institute.*

Psychology

74. Dodson, T. A comparative study of the responses of restricted and non-restricted students to the Bernreuter Personality Inventory. *The Physical Educator,* **7:** 2 (May, 1950).

The author was interested in determining what effect handicaps and special classes

in physical education have upon the personality of the student. The Bernreuter Personality Inventory was administered to a group of students assigned to restricted physical education and a nonrestricted group in an elective physical education class.

The results indicated the handicapped group tends to be more neurotic and introverted and less confident, self-sufficient, sociable and dominant than the normal group. The handicapped group had more cases on each extreme of the dominance-submission scale.

Because of the few cases involved in this study the author reached no definite conclusions but suggests use of personality tests with caution.—*John H. Shaw.*

75. Heintz, E. Adjustment problems of class status. *The Phi Delta Kappan*, **30**: 8 (April, 1949).

The purpose of this study was to determine if social class is a factor in determining the type of adjustment a child will make to the junior high school environment. A series of statistical comparisons of social status to adjustment scores were made on 222 eighth grade pupils in the Rochester Junior High School, Rochester, Minnesota.

Class status was measured on the Sims Score Card for Socio-Economic Status, Form C, adjustment was measured on the Symonds-Block Student Questionnaire and intelligence was measured on the Terman-McNemar Test of Mental Ability, Form C.

Social status apparently is a small but persistent factor in determining the type of adjustment which a child will make to the junior high school environment. Other factors closely associated with it, such as intelligence, education of parents, economic resources and the possession of status objects tending to re-enforce it. Adjustment to school appears proportional to status; the upper class making the best adjustment, middle class next, and lower class third.

Status appeared most pronounced in its effect on adjustment in relation to the curriculum and in the relations with the administration.

In situations calling for an evaluation of the rules and their enforcement middle class pupils enjoyed superior adaptation to other groups.—*John H. Shaw.*

76. Janoff, Irma Z., Lloyd H. Beck, and Irvin L. Child. The relation of somatotype to reaction time, resistance to pain, and expressive movement. *Journal of Personality*, 18, **4**: 454–460 (June, 1950).

Fifty-one sophomores at Yale College were used as subjects. Simple auditory reaction time was measured by response to a loud click, visual discrimination reaction time was measured by response to the lighting of one of two bulbs, and reaction to an electric shock to the leg measured reaction time at shock threshold and reaction time to a strong shock.

Statistically significant results were found between mesomorphy and simple auditory reaction time. Resistance to pain stimulation was negatively related with ectomorphy and positively related with endomorphy. The author concluded that somatotype is not a very important determinant of measures of reaction time and resistance to pain as found in this study.—*Carolyn W. Bookwalter.*

77. Slater-Hammel, A. T. Vision and success in motor performance. *The Physical Educator*, **6**: 1 (March, 1949).

The author reports on a number of studies of vision and its relationship to motor performance. All studies reported seemed to indicate that unusual visual powers

are not required for athletic success. In fact many good athletes appear to be markedly below normal in some visual factors.

Lawson's study on blinking is quoted to show that individuals may actually be without vision due to blinking from 5 to 20% of the time. It is suggested that blinking may be related to athletic errors although the extent of this relationship is at present unknown. It is estimated that vision may be blurred for .55 seconds by a blink which could readily account for inaccuracy in an activity such as batting if the blink should happen to coincide with the pitch. (The ball travels from pitcher to catcher in .4 to .6 seconds.)

Training to refrain from blinking during the crucial period of batting, fielding or throwing is suggested as a possible way of reducing athletic errors.—*John H. Shaw.*

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